Australasian Plant Conservation

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Climate warming and the germination niche
Re-establishing the cycad *Macrozamia riedlei* following mining
Hidden treasures: documenting localised variants of the flora of the Swan Coastal Plain
A practical genetic contribution towards best-practice seed-sourcing guidelines for ecological restoration
An interesting plant community of hypo-saline seasonal lakes in the Muir-Unicup catchment, Western Australia
Engaging with industry in plant conservation—state of play in 2010
Fire responses of threatened flora in Western Australia
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SPECIAL THEME: PLANNING CONSERVATION TO ACHIEVING RESTORATION

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Australasian Plant Conservation

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. **The deadline for the March–May 2011 issue is 12 February 2011.** The theme for the issue is **Plant conservation on Aboriginal / Indigenous lands.** General articles are also very welcome. Please contact Rosemary Purdie if you are intending to submit an article: Rosemary.Purdie@environment.gov.au.

Authors are encouraged to submit images with articles or information. Please submit images as clear prints, slides, drawings, or in electronic format. Electronic images need to be at least 300 dpi resolution, submitted in at least the size that they are to be published, in tif, jpg or gif format. Guidelines for authors are at: http://www.anpc.asn.au/anpc/pdffiles/APCGuideContrib.pdf.

Please send articles, no more than 1200 words, as a MS Word (2000 compatible) or rich text format file, on disk or by email to: Rosemary.Purdie@environment.gov.au.

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Front cover: (main) *Calytrix breviseta*, photo: Andrew Crawford; (right, top to bottom) *Banksia montana*, photo: Greg Freebury; *Verticordia albida*, photo: Andrew Crawford; Vegetation monitoring, photo: Melanie Smith.

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From the Editor

Rosemary Purdie

c/- Centre for Plant Biodiversity Research, Canberra.

This issue of *Australasian Plant Conservation*, issue 19(3), kicks off with ANPC President Bob Makinson's report to the Network's Annual General Meeting held on 26 November 2010. Bob raises a number of issues facing plant conservation generally in Australia and other issues the Network faces. Please read his report, and see if you can become a more active ANPC member—there are plenty of suggestions on the back cover of this issue.

The issue continues on pages 6–12, with a selection of papers presented at the ANPC 8th National Conference in Perth, from 28 September to 1 October 2010; the articles appear in alphabetical order of the first author. Based on the theme *Planning conservation to achieving restoration,* the conference included sessions on Conservation Planning, Soil Health, Taxonomy, Climate Change, Seeds and Genes, and Industry. The booklet with full details of the final program and abstracts of all conference presentations can be downloaded from the ANPC website at <www.anbg.gov.au/anpc/conferences/2010/8th_National_Conference_Program_&_Abstracts.pdf>.

The issue also contains information about Myrtle Rust, a new threat to many myrtaceous species in Australia, and an article on a new partnership between the Australian National Botanic Gardens in Canberra and Tondoon Botanic Gardens in Gladstone. Due to space constraints only three regular items are inlcuded; the remainder will be carried over to the next issue.

One new thing for *Australasian Plant Conservation* (APC) appears in the box below—a list of themes for coming issues and a call for expressions of interest from ANPC members who would like to be involved in their preparation (in addition or as an alternative to preparing an article). This is in response to comments from the ANPC survey of members carried out in early 2010. Respondents made many positive comments about APC as well as suggestions about how it could be improved and/or possible themes for future issues. Three of the themes shown in the box incorporate member suggestions; other suggested themes have been retained for future consideration.

The ANPC Committee greatly values the feedback it received from the member survey. At its meetings in October and November 2010 it discussed feedback on *Australasian Plant Conservation*, including possible changes to its format and content. While the Committee decided to adopt some suggestions, it felt others were not appropriate at this stage or will be investigated during the year. The Committee's response to the various suggestions and its reasons for them has been published on the ANPC website—check it out through <www.anbg.gov.au/anpc/>, and enjoy reading this issue, the first for 2011.

Australasian Plant Conservation—future themes

The theme of the next issue of APC, 19(4) March–May 2011, is *Plant conservation on Aboriginal / Indigenous lands.* Submission details and the deadline are provided on the inside front cover of this issue.

The themes for the subsequent four issues of *Australasian Plant Conservation*, from June 2011 to May 2012, are shown in the table below. If you are an ANPC member and would like to assist in the preparation of any of these issues, please contact the Editor, Rosemary Purdie at <rosemary.purdie@environment.gov.au>.

Issue	Theme
20(1) June – August 2011	Mechanisms for plant conservation on private land
20(2) Sep – November 2011	Conservation and restoration of coastal and estuarine ecosystems
20(3) Dec 2011 – Feb 2012	Monitoring and plant conservation
20(4) March – May 2012	Standards for plant conservation

Although each issue of *Australasian Plant Conservation* focuses on a specific theme, members are also encouraged to submit general articles on any other aspect of plant conservation for each issue.

ANPC Annual General Meeting, 26 November 2010: President's report[1]

Bob Makinson

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ANPC President: Bob Makinson

The biggest developments of 2010 on the plant conservation scene have caught Australia unawares and under-prepared.

The breaking of the decade-long drought over much of central and eastern Australia (but not yet in the west) came without any national consensus on how to adjust our uses of land and water to a less environmentally destructive level. For parts of the agricultural sector it has marked a return to business as usual.

There is a marked lack of political leadership—on both sides—on the Murray-Darling water plan, and the more environmentally aware voices from the farming sector have been drowned out by others. The debate has been focussed almost exclusively on river flows, and not the health of the catchments themselves, which is governed by soil and vegetation cover, or their lack.

There has been no strategic planning, or building of capacity, that would have allowed us to take advantage of the sustained rains to make real strides in revegetation and ecological restoration. As Kingsley Dixon pointed out at the ANPC's recent national conference, we have not built up the tonnages of native plant seed that would enable even substantial local-level restoration, much less strategic levels on the upper catchments.

The arrival this year of Myrtle Rust[2], a member of the Guava Rust complex from tropical America, was foreseen as a risk, and generated several levels of prior plans that related mainly to horticultural and production species, with the potential effect on wild biodiversity noted but not the driver of contingency planning. While much of the planning was good, there was arguably a lack of war-gaming of the actual mechanics of an effective response. We do not yet know how this disease will play out—the effects could be anywhere from moderate to catastrophic. However about 1000 species, half of Australia's native plants in the Myrtaceae family, must at this stage be considered as potentially at risk of decline, together with the ecological communities of which they are part.

There is no benefit of hindsight involved in pointing out that Australia has failed to invest in developing expertise and employment of fungal taxonomists and plant pathologists to focus on the threat of such pathogens to wild biodiversity. Pathologists and mycologists alike have been warning of this shortfall for more than 25 years.

There are no glib solutions to these issues. Changing national priorities to properly value our natural systems and species is a long, agonisingly slow process. People need to work at many different levels and in many ways, but one of them is to build a strong interaction between conservation scientists and practitioners in industry and the community. This is the ANPC's particular mission. Within the capabilities of a fairly small, largely volunteer-based organisation, we will soon have notched up 20 years on the job.

Staffing and governance

Our national office staff (Project Manager Sue Mathams and Office Manager Merryl Bradley) have been working hard on several fronts this year. Sue has been setting up the collaborations and content for six grant-funded courses on Travelling Stock Reserves, which has involved consultation with the very wide range of NSW stakeholders. Sue has also been producing the electronic bulletin *ANPC News*. Merryl has, among other things, been revamping our website and drawing our attention to a lot of issues on which new content is needed (more on these below). Sadly, Merryl has given us notice for early in 2011 to spend more time with family. We are going to miss her greatly.

Longstanding office volunteer Odette Mayne has been joined this year by Liz Myszka, and their contributed time and energy makes a great difference to our ability to get things done.

Our financial accounts are in good hands with Treasurer Adrian Fethers and Office Manager Merryl Bradley. The format for financial reporting to the Committee is very intelligible and seems to answer our needs for forecasting trends. Steady administration of Committee business is by Secretary Phil Ainsley.

We are as ever grateful to the Australian National Botanic Gardens for hosting us physically (our national office) and electronically (our website, phones and email). Particular thanks go to ANBG Executive Director Judy West and General Manager Peter Byron.

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[1] This is a modified version of the report provided to the AGM.

[2] See also page 31 of this issue of *Australasian Plant Conservation.*

Events

We held three events this year—less than in some years, but this goes in cycles of preparation and delivery. Next year will be event-heavy.

In February, a *Translocation of Threatened Plants* course in Perth drew 53 people. Leonie Monks and Dave Coates were key local organisers. Western Australia has the highest use of conservation translocations in Australia, and we were able to draw on experts from the Deptartment of Environment & Conservation (DEC WA) and the Botanic Gardens & Parks Authority. Many attendees were from ecological consultancies and revegetation companies, reflecting both the impact that the minerals boom in the state is having on native vegetation in certain areas, and the considerable investment that some of the mining companies are putting into conservation surveys, management, and remediation. Formerly the preserve of a few companies only, such as Alcoa, now more companies have recognised the need to make a serious contribution. It is invariably 'soft', limited-term money, but the sustained boom has kept it coming, and it has been deployed to make longer-term gains in documenting WA's biodiversity, developing expertise, and running conservation programs. DEC WA plays a major role in securing this investment and directing it to good use; governments in some other states should take note.

A similar translocation workshop was also held in November at Pottsville on the far North Coast of NSW, which drew 40 people and was evaluated strongly. Thanks to the organising group of Sally Jacka, Tricia Hogbin and Sue Mathams, and to additional presenters Maria Matthes, Manfred Jusaitis, Chris Howard, John O'Donnell, Di Brown and Maurizio Rossetto.

Our 8th National Conference was also in Perth, at the end of September. This drew 207 people and was one of our best ever. The organising group are owed a big vote of thanks (Dave Coates, Helena Mills, Leonie Monks, Melanie Smith, Shelley McArthur, Katherine Downes, Grant Wardell-Johnson and Ben Miller, plus Sue Mathams and Merryl Bradley at the Canberra end). Selected papers from the conference are in this issue of *Australasian Plant Conservation.*

Outreach

Our bulletin, *Australasian Plant Conservation*, has continued to publish high-quality information relevant to a wide range of plant conservation issues, under the general editorship of Rosemary Purdie. Themes for 2010 have been:

- Local Government and plant conservation
- Wetlands and plant conservation
- Regrowth—a positive force for plant conservation
- Plant Conservation and linear vegetation remnants.

PDFs of the bulletin are available on the RMIT's Informit website (www.informit.com.au).

Rosemary will be stepping down as APC editor in early 2011, and as this report goes into the editorial process, we have yet to secure a volunteer to replace her. It is a substantial job of work, but an interesting one, and with a well-established routine and a strong group of editorial supporters to assist.

The electronic bulletin *ANPC News* (http://anpcnews.blogspot.com/), edited by Sue Mathams, provides useful information via email or RSS updates. It now has over 500 subscribers, only about 120 of which are ANPC members. It is hard to know how to interpret this: some members may still be unaware of it despite reminders (it is an 'opt-in' system, so you have to subscribe), or some may feel sufficiently well in touch through APC and the website. Or maybe it's just email overload. ***Those members who do subscribe can help us to broaden its coverage by sending in news items relevant to their state or region.*** We need timely notifications of coming events, legislative reviews and submission deadlines, and new information sources (including books, reports, websites, and strategy documents). You can also help by making other people aware of *ANPC News*.

Merryl Bradley and Siobhan Duffy have revamped the ANPC website over the last year, both for look and content. We have been replacing obsolete material with new, and now have a much better capacity to add pages rapidly. ***We are keen to expand the 'Issues and Resources' pages, and welcome suggestions (and better still, draft content) from members and subscribers.*** We have also reworked the 'support us' pages, to improve the information for potential sponsors and donors, and have added a Bequests section. Neither of these will attract support passively—***we need help from members in canvassing potential providers of both these forms of support. Please contact the office to discuss possibilities.***

Above all, you can help build the ANPC and its capabilities by encouraging others to join, both individuals and the organisations you are involved with.

Funding base

Despite prudent management, our funding base remains too fragile, and we do not have the means to run as wide a range of activity as is needed. Our strategic goal continues to be diversification of our income base, as a means of increasing it. We have had some success, but further geographical and funding-source diversification is needed, and especially an increase in the number of ANPC events that are both useful for conservation and also effective in raising steady, not necessarily spectacular, income. ***For this, we need ANPC members (and others) to think of local opportunities and needs that we might be able to meet, and to help us form a local nucleus of active people to realise them.*** We need to think more about having some regular set-piece events each year, as well as reactively chasing grants.

The grant funding scene continues to be poor for conservation organisations, especially in our niche area of expertise transfer and communication. We have one major project grant of $50,000 over three years from the NSW Environmental Trust, for courses in NSW on ‘Vegetation management in Travelling Stock Reserves and similar easements’. We also have useful support ($15,000/year for 2009–11) from the NSW Environmental Trust’s *Leading Environmental Community Groups* program, and $1500 from the Commonwealth *Grants for Voluntary Environment and Heritage Organisations (GVEHO) Program* towards administrative expenses.

While we now have basic Bequests information on our website (see above), we need a sustained effort to canvass solicitors and financial advisors around the country to make them aware of that option for their clients. Anyone with experience in this area, please make yourself known. The same applies to finding sponsors, whether for specific events, publications, or for ongoing general support.

Our events are consistently well attended and bring in a useful surplus, suggesting that we are judging the opportunities for courses about right. Our course fees structure is designed to maintain accessibility for community and individual practitioners as well as professionals, so there is a necessary trade-off between income and access. An upper limit is imposed by how many balls we can keep in the air at any one time.

We are working on reacquiring accredited status (for certificates, diplomas, and some degrees) for at least some of our courses. We are pursuing a partnership with an industry training body to run some pilot courses and see if they work administratively and financially. Courses would remain ANPC-owned and designed events, with the industry body as an administrative partner and brokering connections with venues and regional Registered Training Organisations. We have to see if the financial cloth can be cut several ways and be viable for us.

2011 Strategic Plan renewal

The 2010 Management Committee agreed a process for developing a new Strategic Plan for 2011–2016, using the 2005–10 Plan as a template. The process will involve the following steps.

1. Member/stakeholder focus groups. Two have been held in Canberra, but the opportunity has not yet been taken up in other centres. A discussion template is available. These can occur at any time in the process, but earlier is better. They are an excellent opportunity to gather local members together and can lead to wider interaction. In 2010 we also surveyed all ANPC members on their views for ANPC priorities; a reasonably high return produced informative results which have been taken on board and will inform the Strategic Plan renewal.

2. A dispersed external panel to provide strategic comment. A number of people have been identified who are prominent in strategic conservation issues and/or organisational development, supportive of ANPC, and likely to have useful perspectives.

3. A small, mainly internal panel to look at working group structure and practice. The panel will review our past Strategic Plan working groups, and project-specific working groups, to identify success/problem factors, and to make recommendations for a more sustainable approach.

4. A general call for Strategic Plan discussion papers.

5. Final drafting. The 2011 Committee will convene a face-to-face workshop of a delegated group to draft a new Strategic Plan for wider final comment by members.

The above process is open to ideas and position papers from all members and external supporters at any time. It’s your Network, and we need your input and energy.

Conclusion

I want to thank the whole 2010 Committee for their dedication to the organisation and the cause of plant conservation. Our work during the year has confirmed yet again our ability to tap into local energy and the pro bono time of experts, to produce events and publications with a nationally attractive power. We continue to be unique in our mission at a national level.

Have you renewed your ANPC membership?

ANPC relies predominantly on membership fees, sponsorship and project funding to stay financially viable and thus be able to carry out the range of activities the organisation is now known for, including organising and running regular ANPC conferences, targeted training workshops and publication of *Australasian Plant Conservation*.

If you have not yet renewed your membership, go to the ANPC website at <www.anbg.gov.au/anpc/join.html#member> to download the membership form, or contact the ANPC office by phone (02 6250 9509) or email (anpc@anpc.asn.au).

Climate warming and the germination niche

A. Cochrane

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Introduction

Germination is an important life history phase for obligate seeding species. Seeders need to germinate to persist in the environment after disturbance, with favourable environmental conditions required to ensure recruitment success. Failure to germinate after disturbance events may mean local population extinction.

Temperature is arguably one of the most important climatic variables influencing seeds since it synchronises germination to environmental conditions most suitable for seedling establishment. Seeds will germinate over a range of temperatures, with thresholds above and below which little or no germination will occur. Under climate warming scenarios temperatures are forecast to rise between 2–5°C. If species have specific temperature requirements for germination then climate warming could cause a mismatch between temperatures that seeds experience and temperatures over which germination is able to occur. Such a mismatch in the germination requirements of obligate seeding species could render them vulnerable to decline and extinction. Species that occupy specialised habitats and those inhabiting cooler and wetter climates are likely to be more susceptible to change.

Taking into account the current geographic distribution of species, bioclimatic modelling has been used to predict the future of plant diversity across a number of plant groups in Australia. Hughes *et al.* (1996) predict the displacement of temperature envelopes of *Eucalyptus* species; Pouliquen-Young and Newman (2000) envisage dramatic decreases in the geographic range of Western Australia's eastern goldfields *Acacia* and *Dryandra* species, and Fitzpatrick *et al.* (2008) and Yates *et al.* (2010) forecast range contraction for *Banksia* species in the south-west of that state.

Models use spatial environmental data to infer species' range limits and habitat suitability, but they do not take into account complex biological processes that drive species' distributions and persistence, and are therefore subject to error. The collection of empirical data on biology, ecology and species' interactions would increase the robustness of existing models.

The environmental space in which a species is located is termed its niche. Niche characteristics can be powerful indicators of species' sensitivities to climate change. By measuring one dimension of the niche (e.g. germination) and studying the rate of change in that feature over time (*vis a vis* projected climate scenarios), insight can be gained into the effects of a warming climate on plant species persistence (Cochrane *et al*. in press).

This article describes the use of a temperature gradient system to determine whether such parameters as latitude, elevation, rarity or regeneration strategy influences the germination niche of a range of native species from south-west Western Australia with the aim of assisting in the prediction of species' vulnerability to a warming climate.

Methods

A two-way temperature gradient plate (Model GRD1, Grant Instruments, Cambridge, UK) was used to profile the germination of more than 45 species across fluctuating and constant temperatures ranging from 5°C to 40°C. Seeds were sown on 1% water agar in 35 or 50 mm Petri dishes under a 12 hour photoperiod and monitored for 6–8 weeks depending on species, with seed germination scored every 2–3 days. Percentage germination and mean time to germination were calculated for each cell in which germination occurred. Contour plots were constructed from the resulting raw percentage germination data using Sigma Plot.

Results and discussion

Day and night temperatures are presented as the niche axis, with temperature profiles representing the two dimensional niche space for germination (figures 1 and 2). The plots show points of equal percentage germination connected by germination isopleths. The percentage germination shading calibration shows dark filling isopleths as high germination, light filling as low or no germination. Constant temperatures occur on the diagonal line from the bottom-left corner of the diagrams (lowest temperature approximately 5°C) to the top-right corner (maximum temperature approximately 35–40°C). All points above and below the diagonal line represent alternating temperature regimes, with greatest amplitude at the top-left and bottom-right corners of each graph. Where high germination occurs over a large range of temperatures, the difference in suitability of the niche space is determined by the rate of germination (i.e. fitness contours overlaid on the germination niche) as presented in Figure 2.

Over the range of species profiled, geographic range, rarity and reproductive mode did not appear to be good predictors of temperature limits in the germination niche. As a general rule, rare species did not necessarily differ in the width of their germination window compared to more commonly occurring species (see Figure 1a and 1c). Despite a general lack of relationship between geographic restriction and germination niche breadth, several species confined to the low mountains of the Stirling Range did display a narrow temperature window for germination (e.g. *Sphenotoma drummondii*; Figure 1b).

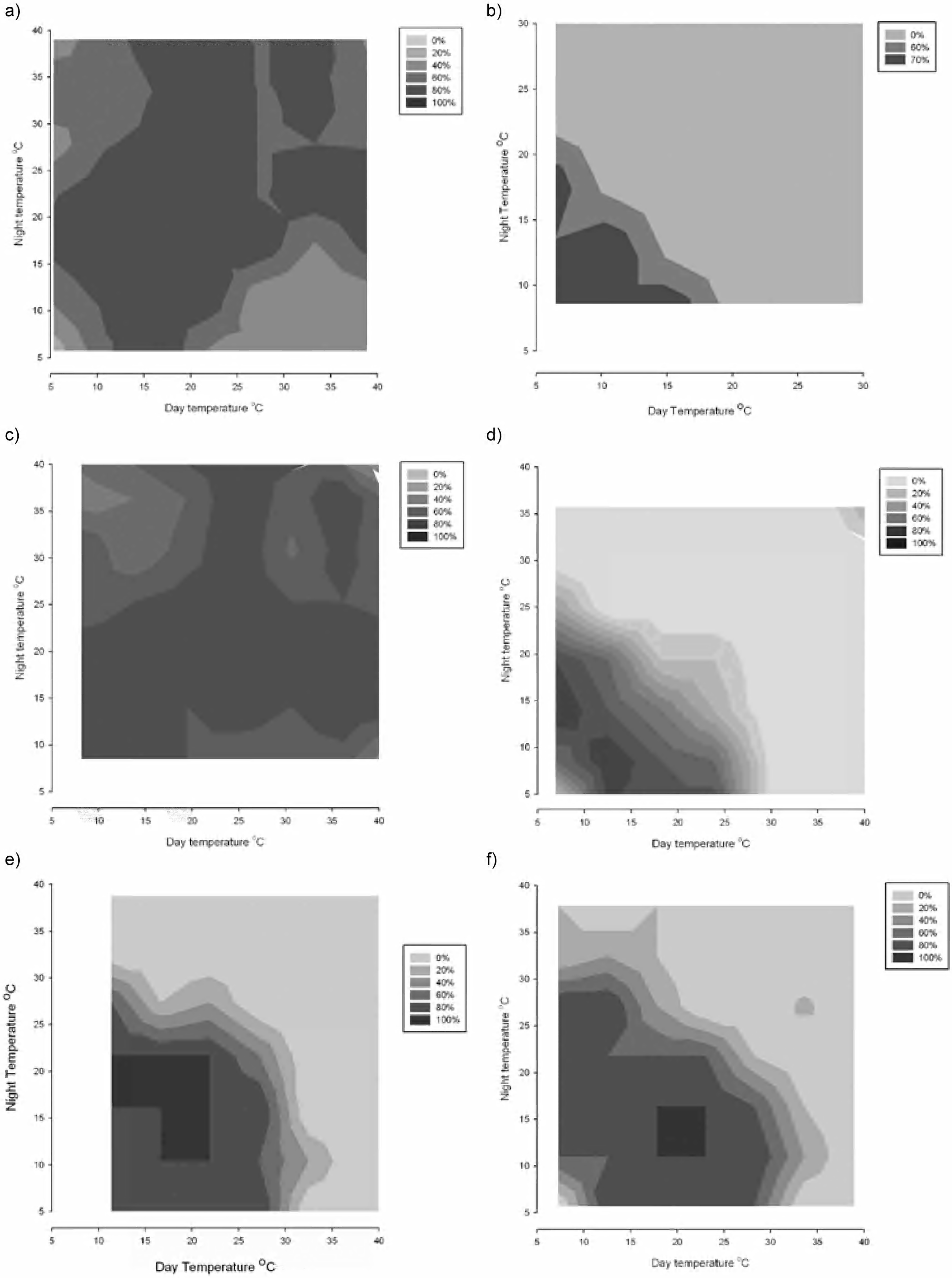

Figure 1. Germination temperature profiles for (a) the rare Eucalyptus nutans*, (b) the rare* Sphenotoma drummondii*, (c) the common* Eucalyptus conferruminata*, (d) the common* Banksia dryandroides *southern distribution, (e)* Banksia speciosa *with southern distribution, and (f)* Banksia lanata *with northern distribution.*

For other geographically restricted species from these upland areas, a wide thermal tolerance for germination suggests that temperature for germination would not be a constraining factor for population persistence or possible range extension under predicted climate warming (data not shown).

In the series of *Eucalyptus* and *Banksia* species screened, there was little difference in the germination niche between seeder and sprouter species (data not shown). There was a tendency for a greater number of *Banksia* species with southern distributions to have a narrow germination niche compared to those with northern distributions (e.g. Figure 1d and 1f), although some *Banksia* species limited to the south coast also showed broad niche tolerance (e.g. Figure 1e). The germination niche for three populations of the widespread *Banksia baueri* differed little across the species' geographic distribution. This suggests for this species that population variation in the germination niche does not exist (i.e. for temperature) (data not shown) and that potentially a single population can be used to define temperature thresholds for germination for the species (i.e. no visible population variation within the germination niche of the species).

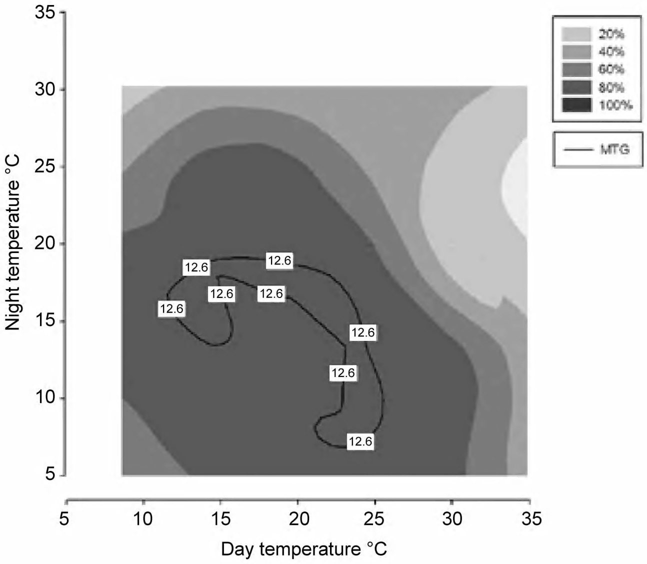

Figure 2. Germination temperature profile for Banksia media *with contours for mean time to germination (MTG) in days overlaid onto profile to indicate optimal temperatures for germination (i.e. highest level of germination in shortest possible time).*

Concluding comments

The available data do not provide any constructive trends to indicate seed germination traits (level or rate of germination) that may identify species' vulnerability to a warming climate. Nevertheless, species with narrow germination windows may be restricted in their seasonality of germination, whereas species with wide temperature windows for germination may be less at risk of recruitment failure (i.e. reduced germination) under future climate scenarios. It is possible that species with a broad germination niche may be pre-adapted to warmer temperatures for germination and therefore less of a conservation concern than those with narrow temperature tolerances.

Short-term process studies like these laboratory incubation experiments using temperature gradient systems can give quick, basic insight to some questions regarding potential climate change impacts on seed germination requirements. For example, if a seed cannot germinate under elevated temperatures forecast under climate warming, then population extinction may occur. This novel seed-based predictive tool could become useful to highlight priorities for conservation actions and in particular, help in influencing choice of populations and sites for species reintroductions and restoration into novel environments.

Acknowledgements

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Urban landscapes supporting plant conservation

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Introduction

The right vision from a property developer and engagement from all stakeholders in that vision will result in the creation of modified landscapes that are aesthetically pleasing, sustainable and that support local plant conservation. Increased community awareness of the importance of sustainability and preserving our biodiversity is driving change. With planning and industry support, urban development could become one of the most valuable resources for plant conservation in already modified landscapes. It has been clearly demonstrated that our community health and wellbeing are directly connected to the health of the environment in which we live. The urban environment which incorporates retained bushland and modified landscapes with 100% indigenous plants and with seed collection and cutting programs from these modified landscapes in turn supports the health of that community.

How urban landscape outcomes achieve biodiversity protection

Indigenous plant modified landscapes are achieved by agreement with the vision, commitment to the final outcome (including the financial commitment), careful planning and the employment of adaptive management practices throughout the development. Understanding and valuing the vision and planning commitment are critical to achieve the desired outcome, with the end result being worth every bit of effort required.

The journey includes the creation of horticultural strategies which:

- incorporate the holism of environmental concerns;
- are compliant with the multitude of statutory environmental requirements;
- deliver community outcomes required; and
- suit the purposes for which they are designed.

Horticultural strategies include assessments of natural assets: flora, fauna connectedness, plant selection opportunities, and biodiversity preservation. These elements lead to the creation of indigenous plant public open spaces and other modified landscapes. It is from these modified landscapes that future plant requirements will be harvested, rather than continuously sourcing from bushland sites. In short, for landscapes to be sustainable they should serve to protect our biodiversity, and aid plant conservation which in turn promotes community health.

Case study—Ellenbrook Development, Malvern Springs

Malvern Springs is the sixth village in the staged development of Ellenbrook, north-east of Perth, in the Swan Valley. Our engagement with this project commenced in 2005 and is still current today. The development vision included preservation of bushland throughout the development (including on building lots) and achieving 100% indigenous plants in modified landscapes (reducing dependence on irrigation).

In 2004, at the time of commencement of the development, it was understood that more than 95% of plants included in modified landscapes and gardens in Western Australia were either exotic or species from the eastern states.

This development was the first to aim for 100% site specific indigenous plants. To achieve this, a point of reference and an agreed vision was required which was published as *Invigorate your life. It is a place that helps to achieve vitality and invigorate your life whilst living in a beautiful place – well designed and in tune with nature*. This vision was used to clarify objectives, critical issues and actions.

Local trees at Ellenbrook destined for future landscapes. Photo: Sue Dempster.

The planning process provided opportunity to incorporate industry best practice principles, undertake baseline surveys and anticipate any threats to achieving the required outcomes through risk assessment and mitigation strategies.

Key features to create indigenous plant modified landscapes (many of which were beyond statutory requirements) included:

- protection and retention of local bushland and wetlands in public open spaces exceeding the statutory requirement of 10% of the development area;
- recycling natural assets (including logs, topsoil, propagation materials and mulch) for reuse in landscapes and gardens;
- fauna trapping, tracking, observations and monitoring and relocation;
- working with the land's topography by going around trees, altering roads, and including bunds; and
- community engagement to share the knowledge on the cultural heritage of the plants and natural assets incorporated into the development.

Case study—City of Joondalup

The City of Joondalup encompasses 22 suburbs which are predominantly residential regions, covering an area of nearly 100 square kilometers. The City's natural assets include 204 ha of natural bushland, 490 ha of reticulated parks and 116 ha of dry parks. There are three soil types within the City—Karrakatta, Quindalup and Cottesloe. A Landscape Master Plan evolved from the City's vision—*Landscaping in the City of Joondalup will be innovative, distinctive, functional and appealing, and valued by residents and visitors and will evoke a sense of ownership and pride amongst its residents*.

The Landscape Master Plan contains key focus areas which include City-wide landscaping image, management and development, Joondalup Central Business District, parks, verges and median strips, and community buildings. Central to the outcomes of these key focus areas is the creation of the provincial indigenous plant mother-stock growing program. The City is the first local government municipality in Western Australia to authorise such an extensive program. The propagation material required for the growing program is collected from the City's local natural areas and may be supplemented by salvaging collections as opportunities become available.

Additional programs to support this undertaking include:

- assessments, monitoring and site evaluations for bushland, plant stock and landscapes programs;
- plant and landscape program training, and project inductions;
- community engagement and connection; and
- interdepartmental integration and vision adoption.

A constant theme is to share the City's vision with suppliers, contractors and stakeholders. This is supported by planning, monitoring, risk assessments and regular reporting on reaching milestones. This commitment from the City derives from their understanding that local plants provide many benefits which include substantial water saving to their community and their environment, to combat climate change and to preserve and protect the City's biodiversity.

Summary

The landscapes created at Ellenbrook and the City of Joondalup serve to provide plant stock for future landscapes. This results in reducing pressure on the retained bushland through continual propagation material being collected and to minimise the introduction of exotics and other non-natives into the area. It will also reduce water dependency within the modified landscapes and increase the flora/fauna interrelationships.

The Ellenbrook development is a recognised, award-winning water-wise development and is a leading example of how to conserve bushland in a greenfields development. The result is biodiversity protection which then results in a healthier community. The City of Joondalup's vision provides an example for local government on how planning can result in the protection of biodiversity, create landscapes with the valued local plants and provide community enjoyment from the benefits derived from local flora.

The application of local plants in modified landscapes serves to create beautiful landscapes, biodiversity protection, plant conservation and healthier communities. Horticultural strategic planning makes this easier. In short, plan right to plant right.

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Re-establishing the cycad *Macrozamia riedlei* following mining

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Introduction

Alcoa of Australia has mined bauxite for the production of aluminium since 1963 in Western Australia's northern Jarrah (*Eucalyptus marginata*) forest (Figure 1). While the company has made significant advances in its rehabilitation methods some plant species still pose a challenge in restoring native Jarrah forest vegetation (Koch 2007). The cycad *Macrozamia riedlei* (Zamia), is a key species in the Jarrah forest, but is under-represented on rehabilitated sites (~50/ha) compared with densities in adjacent unmined forest (~1000/ha).

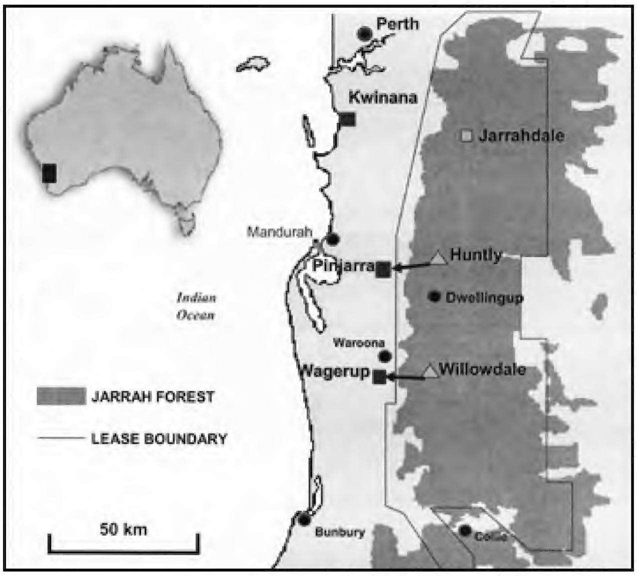

Figure 1. Bauxite mining and refinery locations for Alcoa World Alumina in Western Australia (from Gardner and Bell 2007).

Mining bauxite and rehabilitation

The bauxite is relatively shallow and is accessed by removing the overlying gravelly soils, and then blasting or ripping the lateritic cap-rock and friable bauxite layers. The subsequent rehabilitation includes ripping the mined pit floor using heavy machinery, replacing overburden and seed-rich topsoil, and then ripping the final surface while following the contours of the land (Koch 2007). Logs and rocks are returned to provide fauna habitat, and direct seeding and fertiliser is applied to assist the re-introduction of flora. Zamias are re-introduced by hand burial of the large seeds in winter in the newly rehabilitated areas.

The project

This study was designed to better understand the survival and growth of Zamia in the post-mining environment. To achieve this, changes in Zamia density and cover over time were analysed from 21 years of monitoring data collected from 900 permanent 80 m^2 plots established by Alcoa at three mines: Willowdale and Huntly (both operational) and Jarrahdale (decommissioned in 1998) (Figure 1). Zamias were also harvested from 2–21 year old rehabilitated mine sites (Huntly) to compare size and biomass with age (Figure 2). At the 21 year old site these measures were made for burnt (nine months post-fire) and unburnt areas to determine the impact of fire on the growth of the species. The structural characteristics of all sites from which Zamias were harvested were recorded to identify habitat change with time.

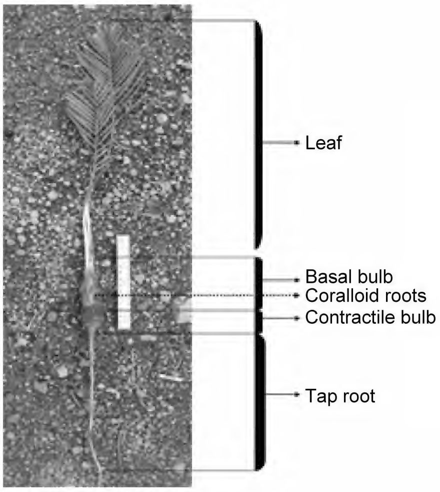

Figure 2. Anatomy of a typical immature specimen of Macrozamia riedlei *(Zamia). Labels indicate the various plant components that were measured for size and biomass to assess growth over time. Photo: Renae Douglas.*

What was found?

Zamia establishment and growth

The density of Zamias nine months after seeding on the rehabilitation sites was less than 100/ha, despite sowing of up to 600 seeds/ha (<20% establishment). Recent work to refine hand planting techniques and putting in place more stringent auditing of contract planting teams has resulted in establishment rates of up to 35%. However, regression analysis suggested that the survival of Zamias on mined sites declined with time since establishment, and thus survival remains an issue.

Plant cover per surviving plant, and, more importantly size and biomass all increased with age (Table 1). This confirmed that the Zamias were growing, albeit at a slow rate (i.e. reaching 2-10 cm^2 across after 15 years!). It was extrapolated that these plants would take 295 years to reach the size of Zamias in unmined forest, a seemingly unnaturally long time even for a slow growing species (Grove *et al.* 1980).

Table 1. The results of linear regression analysis of plant size and mass with plant age (2–21 years) for Macrozamia riedlei *(Zamia) harvested from rehabilitated sites at Alcoa's Huntly mine (n=42).*

Plant component	r^2	*p*-value (ANOVA)
Dry mass		
Whole plant	0.086	0.066
Leaf + basal bulb	0.182	0.005
Coralloid roots	0.046	0.180
Contractile root	0.003	0.721
Number of leaf bases	0.259	0.001
Fresh length		
Whole plant	0.296	<0.001
Longest leaf	0.228	0.002
Basal bulb	0.336	<0.001
Contractile root	0.092	0.054

The impact of habitat changes over time

The fast growth of other understorey and overstorey species on the mined sites suggested that the slow development of Zamia seedlings was due to intense competition (Table 2). It is likely that by 12 years when shrub and tree cover peaks (70% and 60-70% cover respectively) Zamias would struggle to survive and grow. This is consistent with our observation that some Zamias up to 21 years old were no larger than those at 12 years old.

In the unmined forest Zamias show a flourish of growth immediately after fire, consistent with the response of other co-existing resprouter species (Grove *et al.* 1980; Korczynskyj and Lamont 2005). Also, coralloid root growth and the associated increase in the rate of nitrogen fixation, a characteristic of this species, is greatest one year following fire and considered important to the nitrogen balance of the Jarrah forest (Grove *et al.* 1980). Similarly, in rehabilitated areas 21 year old Zamias burnt nine months previously were larger and heavier than unburnt plants. However, only the leaf fresh weight was significantly greater.

Conclusion

Effort to refine seeding techniques is clearly bearing fruit, and while survival and growth is tenuous this study reveals hope to return Zamias to the mined landscape. Furthermore, the use of prescribed fire may have merit for improving growth of Zamias on rehabilitated sites: temporarily stimulating growth, while reducing competition. Future research should further explore the effect of fire on Zamias growing on rehabilitated sites, and measure recruitment, establishment success and growth rates of Zamias in unmined forest to allow comparison with rehabilitated areas.

Acknowledgements

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Table 2. Structural characteristics of rehabilitation sites of different ages since bauxite mining at Alcoa's Huntly mine.

Age (yrs)	Burnt or Unburnt	Leaf litter cover (%)	Leaf litter thickness (cm)	Mean height of trees (m)	Tree canopy cover (%)	Ratio of dead:alive plants	Shrub cover (%)	Shrub height (m)
21	UB	100	10	10–15	60	70:30	50	1–3
21	B	80	2	8–10	70	90:10	20	<1
18	UB	100	5	8–10	70	60:40	40	1–2
17	UB	100	10	6–10	60–70	50:50	50	2–3
12	UB	100	5	4–6	60–70	70:30	70	2–3
9	UB	100	10	4–6	60	40:60	40	<1
6	UB	30	2	4–5	40	40:60	30	<1
5	UB	10	1–2	4–5	10	40:60	10	<1
2	UB	0	0	0	0	0:100	2	<0.5

Reconstructing new populations of the endangered *Rutidosis leptorrhynchoides* (Button Wrinklewort) at two sites in south-western Victoria

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Introduction

Native grasslands of south-eastern Australia have been reduced to one per cent of their historical range. Severe fragmentation of this once widespread flora poses a serious threat to the viability of many species that exist as small and isolated populations (Morgan 1998). *Rutidosis leptorrhynchoides* (Button Wrinklewort), a multi-stemmed, herbaceous perennial is an Asteraceae species endemic within these broader temperate south-eastern grassland communities. The species is listed as threatened under Victoria's *Flora and Fauna Guarantee Act 1998* and as endangered under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. Only 20 natural populations of *Rutidosis* are thought to remain within two broad zones of south-eastern Australia—one across New South Wales and the Australia Capital Territory and the other across southern and south-western Victoria (Young *et al.* 1999).

Issues to consider

Rutidosis seed is transient in the seed bank and is typically dispersed less than 0.5 m from the parent plant. *Rutidosis* also exhibits a self-incompatible breeding system (characteristic of many Asteraceae) which functions to reduce the risk of inbreeding depression. Such systems work most effectively in large, genetically diverse populations. However, half of these populations consist of low numbers of individuals (<200) and studies have confirmed that these small populations are prone to inbreeding depression (Morgan 1998; Young and Murray 2000).

Of the 20 south-eastern populations, the northern 15 are primarily diploid in regard to chromosome number, while the southern communities are wholly diploid, wholly tetraploid or mixed (Brown and Young 2000). These authors argue that because of the high risk of sterility in triploid plants, establishing new founder populations should avoid introducing mixed ploidy populations which would be counter-productive and wasteful of expensive resources. Conservation of this species should thus look to increase the size and genetic characteristics of existing small populations. When attempting to reconstruct new populations, programs should also consider the implications of population size and the genetic make-up (where this information exists) of source populations.

On-ground activities

Greening Australia's Grassy Groundcover Research Project has for some time investigated the reconstruction of species-rich grassland by direct seeding (Gibson-Roy *et al.* 2010). Originally thirteen 1 ha trial sites were established across south-western Victoria to test methods of direct seeding and weed control. In recent years a number of other sites have been established, consolidating learnings from the initial study. One such site was initiated in 2008 in partnership with VicRoads (Western Region). It aimed to reconnect high quality roadside remnants separated by historically planted non-endemic native tree plantations on the Glenelg Highway near Wickliffe in the state's south-west (Carland and Kennedy 2010).

During the late 1980s and early 1990s attempts were made to re-establish populations of *Rutidosis* at five sites in south-western Victoria (four using tube stock and one seeded) (Young and Murray 2000). Assessments of survival in 1996 showed that while there had been some reductions and some increases in numbers across the sites (from 25 to 300 individuals remaining across the five sites) the species remained at each. Aware of these encouraging outcomes and buoyed by the Grassy Groundcover Research Project's experience in reconstructing grassland by direct seeding, a further goal of this project was to re-establish two new founder populations of *Rutidosis* within both newly reconstructed grasslands.

Cognisant of the preceding discussions concerning population size, breeding systems and ploidy levels, seed from a nearby small (n=26) remnant tetraploid population located 3 km from the sowing site was combined with seed from a larger (n>5000) population (also tetraploid) located approximately 100 km from the seeding site. Small amounts of seed were taken from as many reproductive individuals as possible (i.e. 500+ in the large population) over the whole period of seed ripening and bulked and sub-sampled to obtain propagation material. From these small but diverse samples of seed from both source populations, plants were propagated to establish a production population (n=500). *Rutidosis* was grown as part of a larger seed production program, along with many other local species (Figure 1). The aim of the seed production system was to produce the quantities of seed required to undertake a field-scale seeding program.

Outcomes

Seed from the production program and a limited number of plants (approximately 150) were introduced onto bare/cleared sites in spring of 2009 using the Grassy Groundcover Research Project's purpose-built seeder (Carland and Kennedy 2010). Since that time emergence and establishment from a whole suite of sown species has been extremely encouraging (Figure 2). In regard to *Rutidosis*, surveys undertaken 12 months following seeding show that up to 90% of the planted individuals have survived at both sites. More importantly, seedling emergence from sown seed is widespread and consistent, indicating that new populations of >1000 individuals have been established. Earlier sowings of the Research Project have confirmed that, in most cases, survival from individuals present at this point (post-seeding) is largely maintained, given appropriate management regimes.

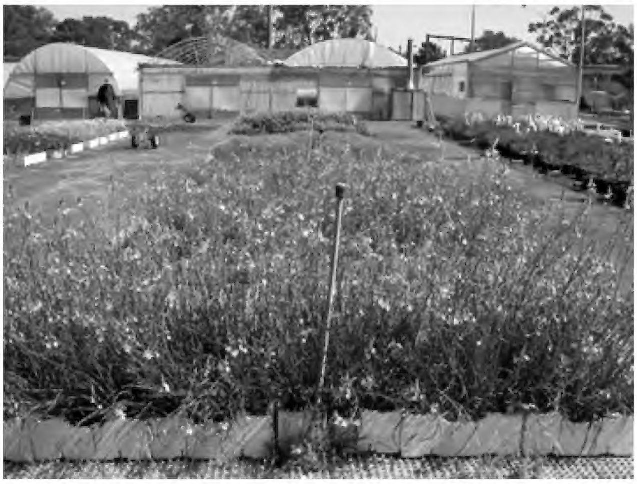

Figure 1. A range of species (including Rutidosis leptorrhynchoides*) growing in a containerised production system used to produce the desired quantities of seed for sowing at field scale.*

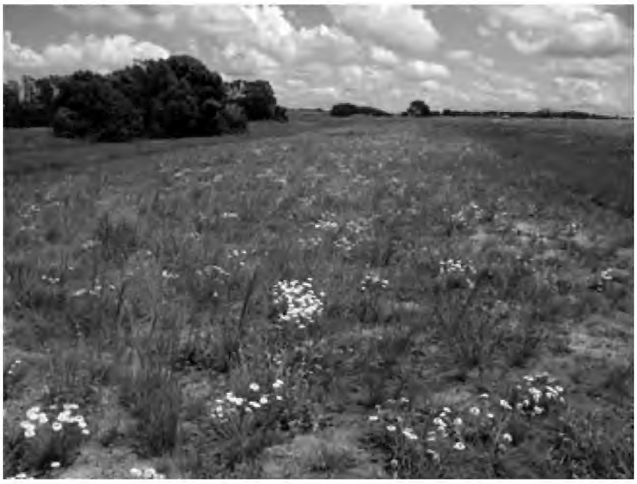

Figure 2. A diverse range of grassland species establishing at one of the two sites. Across both sites >1000 Rutidosis leptorrhynchoides *are present.*

Summary

This Grassy Groundcover Research Project trial aimed to reconstruct species-rich grassland and to recreate two new populations of the nationally threatened *Rutidosis leptorrhynchoides*. While it is still early in the establishment phase, it seems likely that both goals will be achieved. The *Rutidosis* component of the program also highlights how conservation and restoration projects can utilise and benefit from a breadth of important information generated in aligned disciplines (such as the genetic studies used to informed decisions at our sites). In doing so they may increase the likelihood of success in restoring viable and persistent native systems.

Acknowledgements

Thanks go to Frank Carland and Natasha Kennedy of VicRoads (Western Region), David Franklin and Ron Woff of Franklin Plant Native, Rod White of Greening Australia and Simeon Buckley for their assistance and support in undertaking this project.

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Progressing from single species recovery planning to multi-species recovery across the landscape: a case study from the Hunter Valley, New South Wales

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The native vegetation of the lower Hunter Valley has been extensively cleared since European settlement, with less than 30% remaining. The remnants are subject to a range of threatening processes, including ongoing habitat loss and habitat degradation. Consequently, the area supports at least 65 threatened entities listed under the NSW *Threatened Species Conservation Act 1995*, including nine ecological communities, 46 animal species and 10 plant species. Seventeen entities are also listed under the national *Environment Protection and Biodiversity Conservation Act 1999*.

Single species recovery planning was achieving outcomes

The Department of Environment, Climate Change and Water (the Department) commenced the Hunter Valley Threatened Flora Recovery Program in 2005. The program applied single species recovery framework to a handful of threatened species and ecological communities, including the critically endangered *Persoonia pauciflora* and the threatened ecological community Kurri Sand Swamp Woodland (Hogbin 2005).

The program was supported by an active recovery team and achieved numerous outcomes, including:

- a reliable local scale vegetation map and classification (DECC 2008);
- an experimental threatened ecological communities restoration project;
- a threatened species teacher resource kit;
- various community education and awareness activities; and
- establishment of a Crown Conservation Reserve protecting habitat for numerous threatened species and ecological communities.

Despite its success, the recovery program was addressing the conservation needs of only a few of the numerous threatened entities occurring in the region.

In late 2009, our focus expanded to developing the Cessnock Biodiversity Conservation Program, which seeks to address the conservation needs of all 65 threatened entities across an area of 70,000 ha. The area covers the valley floor region of the Cessnock Local Government Area and was defined by the DECC (2008) local scale vegetation map and classification for the area.

Cessnock Biodiversity Conservation Program

The Cessnock Biodiversity Conservation Program addresses the conservation needs of all 65 threatened entities by:

- developing a landscape conservation plan that highlights priority areas for conservation across the landscape and also opportunities for rehabilitation and revegetation;
- identifying 'local focus areas' where the landscape conservation plan may not adequately address the conservation needs of particular threatened species;
- building upon existing threatened species recovery projects and complementing other threatened species protection mechanisms;
- facilitating implementation of the landscape conservation plan through landscape facilitation projects; and
- encouraging and facilitating collaboration and community involvement in threatened species recovery (Figure 1).

Figure 1. A 2009 Hunter Valley Threatened Species Mystery Tour proved to be a great way to educate the community about their local threatened species. Here we consult with tour participants regarding the Cessnock Biodiversity Conservation Program. Photo: Phoebe Trongchittham.

Developing a landscape conservation plan

The Biodiversity Forecasting Tool (Figure 2) was used to identify conserve priorities across the landscape. The tool models the potential loss to biodiversity if a particular area was to be cleared. Areas with a high conserve priority are those that, if lost, will have the greatest impact on biodiversity. They tend to be larger patches, well connected, in very good condition, and supporting rarer vegetation types.

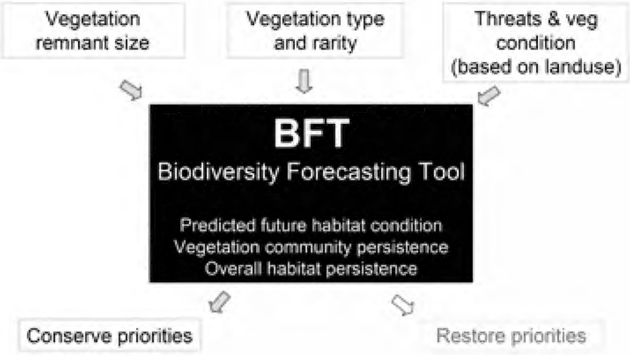
Vegetation remnant size
Vegetation type and rarity
Threats & veg condition (based on landuse)
BFT
Biodiversity Forecasting Tool
Predicted future habitat condition
Vegetation community persistence
Overall habitat persistence
Conserve priorities
Restore priorities

Figure 2. The Biodiversity Forecasting Tool is a GIS based approach to regional conservation assessment that has been applied to a wide range of assessments and planning activities across New South Wales (DECC 2009). The tool models the conservation value of every location in a regional context (taking into account vegetation type, rarity, condition, and remnant size) and predicts conserve priorities based on predicted future habitat condition and persistence. The model also identifies restore priorities, but these were not used in our planning process.

Identifying opportunities for rehabilitation and revegetation

Five key landscape corridors were identified based on the location of priority conserve areas. These corridors provide focus areas for rehabilitation and revegetation works and support the conservation of priority conserve areas. Areas of disturbed vegetation (canopy only or regrowth) within the corridors or adjacent to priority conserve areas have been mapped as opportunities for restoration. Cleared areas within the priority conserve areas have been identified as opportunities for revegetation.

Local focus areas: filling the gaps in the landscape conservation plan

Landscape conservation planning, if implemented effectively, will address the conservation needs of many threatened entities. For example, if all priority conserve areas were protected, managed, and supported through appropriate habitat restoration, the vulnerable plant *Acacia bynoeana* would be adequately conserved. On the other hand, there are threatened entities for which landscape conservation will not be sufficient. For example, the critically endangered *Persoonia pauciflora* would likely still require additional recovery efforts to ensure its persistence.

All 65 threatened entities were assessed for whether they would likely be adequately conserved through effective implementation of the landscape conservation plan. Six of the nine threatened ecological communities, seven of the 10 threatened plant species and all 46 threatened fauna would likely be adequately conserved. Only six threatened entities are unlikely to have their conservation needs met by landscape conservation. Five local focus areas have been identified to address the conservation needs of these six threatened entities. An overall objective and broad recovery actions have been identified for each focus area.

Facilitating implementation of the Cessnock Biodiversity Conservation Program

We now have a clear plan identifying areas that need to be protected and restored, and also areas where local focus projects would be of benefit. Through identifying clear priorities and providing advice, the Department hopes to facilitate sound decision making and to encourage and facilitate the involvement of landholders, individuals, community groups, schools and other government departments in implementing threatened species recovery projects.

Given the need to engage with a diverse and extensive range of stakeholders, it was decided to present the information as a poster style plan, identifying priorities geographically across the landscape. This innovative approach has been well received by other public authorities and the community.

Conclusion

The methodology used has provided an efficient and effective approach to integrating landscape conservation and the conservation of individual threatened species. Recommendations are already being used by other stakeholders in decision making, targeting of funding for on-ground works, and in project development.

Acknowledgements

The Department's project team members include Andrew McIntyre, Lynn Baker, Mick Roderick, Lucas Grenadier, Paul Houlder, and Katrina McKay.

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Ongoing recovery of *Acacia chapmanii* subsp. *australis*: a case study in adaptive management

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Following the recognition of *Acacia chapmanii* subsp. *australis* at a Commonwealth and State level as a declared rare and endangered flora, it was observed that its only known population in a conservation reserve was in rapid decline. Other known populations were aging (see Figure 1) with little recruitment, and confined to narrow linear remnants on road and rail reserves. Whilst little was known about the biology of the species, to save the reserved population it was decided some immediate actions were needed based on the available knowledge of *Acacia* species in general. With these uncertainties an adaptive management approach was used which enabled management intervention using scientific principles based on the best available knowledge.

Adaptive management is a stepped approach based on a scientific model with set goals and hypothese tested, with replicated experimental treatments and controls (Blumstein 2007). This approach enables decisions to be made on management strategies as soon as conclusive results are evident.

Phase one: autumn burn trial, 2004

After elimination of factors such as *Phytophthora cinnamomi* and rising saline water tables, the most likely factor contributing to decline appeared to be lack of disturbance, such as fire, with no recorded fire in over 20 years. As many *Acacia* taxa in the transitional rainfall zone of south-west Western Australia are stimulated to germinate by the heat of a fire, the initial experiment utilised a control burn of small plots designed to have minimal impact on the majority of the community in which the species occurs. The soil seedbank was unknown, so previously collected seed was also used in the trial plots.

Method

Twelve plots each 3 m x 3 m were chosen at random within the population. All plots were fenced to exclude grazing with six burnt and six unburnt. Seeds were planted at a depth of 5 mm in burnt and unburnt plots using a 60 cm Perspex template.

Results

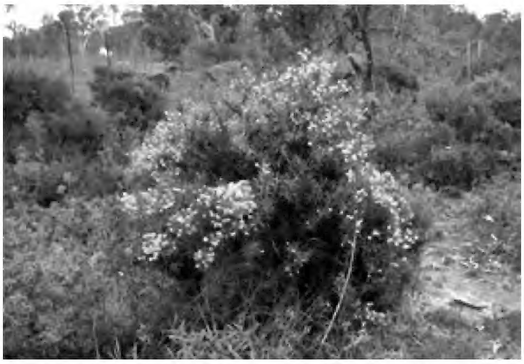

Figure 1. Acacia chapmanii *is a compact bush growing to about 1 m in height. This bush is showing signs of senescence. Photo: Pru Dufty.*

As with similar *Acacia* species (Yates and Broadhurst 2002), fire killed adult *A. chapmanii* but initiated seed germination. The mean initial seedling density in burnt plots was 17.6 plants/m^2 but no seedlings derived from soil-stored seed were recorded in unburnt plots. Monthly monitoring over the first 12 months showed that 43% of planted seed and 50% of soil-bank seed that initially germinated survived to seedling stage.

Management outcomes

The experimental burns showed that fire stimulated seed germination, that there was a sufficient seed bank in the soil, and that in burnt plots, seedlings established following germination. A number of seedlings not evident pre-burn also established following the fire.

Phase two: ecosystem scale behaviour and herbivory impacts, 2005

The success of the experimental trial led to the decision to measure ecosystem scale behaviour and impact on the floristic community in general following a simulated autumn fuel reduction burn, which more closely resembles a wildfire. Impacts to be measured were if regeneration of *A. chapmanii* was similar to the experimental burn, the influence of herbivory on seedling survival, and the impact of fire on the floristic community overall.

Method

Nine plots (3 m x 3 m) were chosen at random within the population. A survey of the presence and density of all plant species present was undertaken on all plots. A normal Department of Environment and Conservation fuel reduction burn was conducted in May 2005 (Figure 2) to include six plots, leaving three as unburnt and unfenced controls. Three burnt plots were fenced to exclude grazing.

The density of *A. chapmanii* was assessed in the spring of 2005, 2006 and autumn 2007 in order to quantify seed germination and seedling survival.

Results

Seedling emergence and establishment of *A. chapmanii* following the fuel reduction burn was in the same order as after the experimental fire in phase one. Seedling survival in open burnt plots was much lower than in fenced burnt plots. No seedlings were present in unburnt plots. Regeneration of *A. chapmanii* had a patchy distribution due to poor seedling emergence and establishment partially under the canopy of a *Eucalyptus wandoo*. Richness and diversity was greater post-burn, with 135 species present compared with 44 species pre-burn.

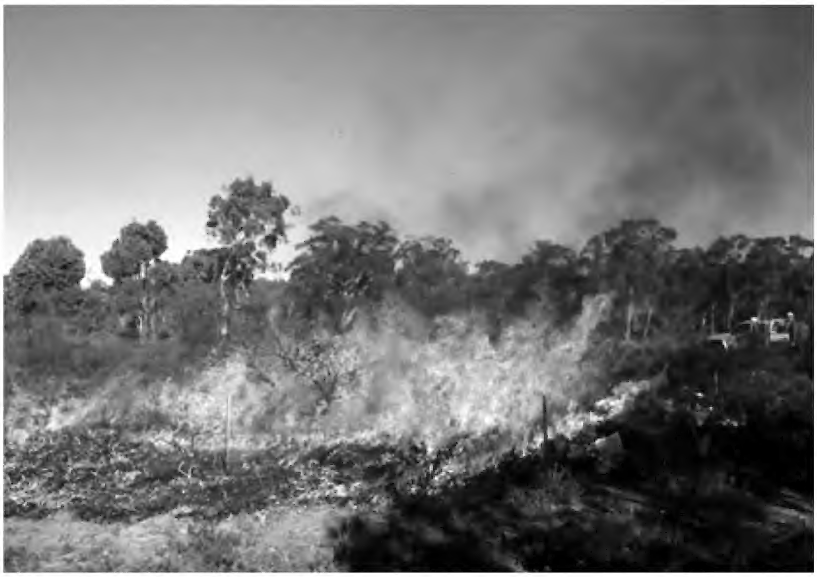

Figure 2. Simulated wildfire burn carried out in a large plot of Acacia chapmanii*, May 2005. Photo: Robert Huston.*

Management outcomes

Implementing a normal fuel reduction burn showed that *A. chapmanii* germinated and established successfully in fenced plots, but that there was a large herbivore impact, with low seedling establishment in unfenced burnt plots compared to fenced burnt plots. Scat counts identified significantly more visitations by kangaroos than rabbits. Structural change has taken place with the establishment of *E. wandoo* seedlings recruiting where they were not established previously.

Phase three: maximising survival of *A. chapmanii* seedlings, 2007

In order to maximise the number of seedlings establishing following the normal fuel reduction burn, it was decided to fence the whole area where this burn took place to protect the total area from herbivores.

Results

Following the fencing of the total burn area the 2009 assessment found that *A. chapmanii* seedlings had established in the burnt and now fenced plots, two and three years following the fire. The density of seedlings in the initial fenced plots was similar to the density recorded in 2006. In contrast, the density of seedlings in the unfenced plots which had been heavily grazed had significantly increased following the erection of the fence. *E. wandoo* seedlings have established within the burnt area.

Ongoing management implications

Our work has shown that reduced fire frequencies mean populations of *A. chapmanii* that become moribund due to natural aging of the plants cannot recruit new seedlings. Absence of recruitment in senescing communities does not appear to be related to the soil seedbank. Once fire occurs, regeneration is cued but the burnt areas become a focus for animals attracted to the succulent regenerating new growth. Grazing severely reduces seedling survival, and exclusion of grazers from newly burnt areas is necessary to ensure sufficient seedlings survive to replace adult plants.

A number of other species also established within the burnt area, with indications that some species may become more dominant than they were prior to the fire. Following the 2005 fire, there was extensive germination of *E. wandoo* seedlings where previously the vegetation had consisted of a heathland community. Further research needs to be undertaken to understand how *A. chapmanii* will cope in future years under the canopy of an over-storey of *E. wandoo.*

Post-fire rainfall and temperature also affect germination (Knox and Clarke 2006). There were near average rains the winter following the 2004 burn, and exceptionally high summer rains following the 2005 burn. The importance of rains following a burn need to be evaluated.

Overall, carefully managed fire regimes and *in-situ* management will be required to ensure the persistence of stable populations of *A. chapmanii.*

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Hidden treasures: documenting localised variants of the flora of the Swan Coastal Plain

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Introduction

South-west Australia is well known as a biodiversity hotspot for flowering plants, with a known flora of over 8000 species and estimates of another 15–20% still to be named. The Swan Coastal Plain (the Plain), which includes most of the capital Perth, is a natural bioregion of mainly sandy soils stretching from Jurien Bay to Dunsborough. Several decades of detailed floristic studies (involving over 1100 quadrats and several hundred bushland areas) have recorded over 2500 native taxa for the Plain (Gibson *et al.* 1994; Keighery *et al.* 2008; Webb *et al.* 2009). While the principal aim of these studies was to understand the patterning, distribution and regional conservation of the native vegetation and flora (Government of Western Australia 2000) it has also enabled the compilation of a substantial database of species with attached ecological data. These detailed records and observations have enabled us to demonstrate that the flora includes a large number of distinctive localised variants of 'widespread' species.

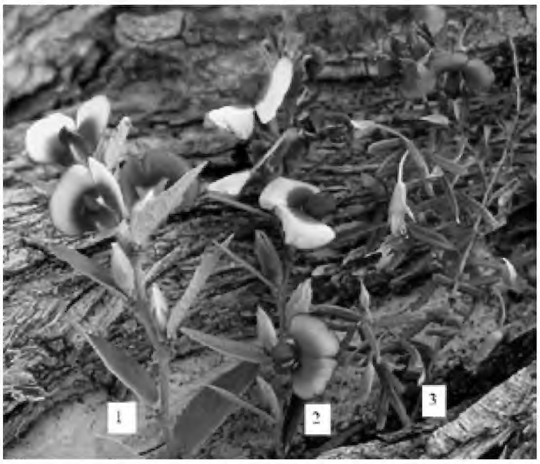

Figure 1. Three Bossiaea *species that are found on the Plain, from left to right,* Bossiaea ornata *(1, widespread, uncommon in the Foothills);* Bossiaea *sp. Waroona (2, Foothills) and* Bossiaea eriocarpa *(3, widespread on Plain and elsewhere). Photos: Bronwen Keighery.*

Patterns of differences

The two major drivers of speciation on the Plain are distinctive habitats related to the different landform/soils and water availability, particularly patterns of inundation and waterlogging (here termed wetland habitats). Five major landforms are distinguished on the Plain: three parallel sand dune systems, from the coast inland: the Quindalup (Holocene), Spearwood and Bassendean Dunes; and inland the alluvial Pinjarra Plain and the alluvial/colluvial Foothills.

Landform/soils

On the Plain a number of taxa have very different forms occurring on different landforms and their associated soils. One example is the very common and well known pea Eggs and Bacon (*Bossiaea eriocarpa*). It was found to be a variable, widespread species that contains at least five distinct species, including two which regularly co-occur in the Foothills (Figure 1). Some of the forms re-sprout; others are killed by fire and re-seed.

Some other taxa that show similar speciation patterns are:

- *Banksia sessilis*, with *B. sessilis* var. *cygnorum* on the Spearwood Dunes;
- *Grevillea bipinnatifida*, with subsp. *pagna* on the Pinjarra Plain;
- *Eremophila glabra*, with two subspecies on the Plain, subsp. *albicans* on two coastal dunes (Quindalup and Spearwood) and subsp. *chlorella* in a few wetlands on the Pinjarra Plain and Dandaragan Plateau; and
- '*Grevillea thelemanniana* group', with *G. preissii* on the shallow soils over Tamala limestone in the Spearwood Dunes and two subspecies of *G. thelemanniana* on the Pinjarra Plain.

Common speciation patterns relate to coastal locations (Quindalup and Spearwood Dunes) and the inland Pinjarra Plain/Foothills. A considerable number of taxa are yet to be formally recognised. Further detailed work will result in the separation of additional taxa in what is presently considered a single taxon, even when the species has been subject to recent taxonomic revisions. For example *Acacia pulchella* and *Hovea trisperma* both have large number of forms associated with different landforms/soils.

Wetland/dryland taxa

Wetland forms of more than 200 taxa have been observed. The water regime of the wetlands is a key factor, as is the landform/soil group in which the wetland occurs. For example what were previously considered wetland and upland forms of *Jacksonia sericea* are now considered to be separate species. These taxa also grow in different soil/landforms. Other examples include *Eremophila glabra* and '*Grevillea thelemanniana* group' as described above. Wetland/dryland patterns are also found in *Verticordia plumosa* and *Chamaescilla gibsonii* (wetland) and *C. versicolor* (dryland).

Using the information in conservation planning and management

If we are to conserve the biodiversity (communities, species and genes) of the Plain and provide guidance for revegetation/restoration activities there, we need to document and be guided by this abundant variation and hence rapidly changing taxonomic landscape. A simple message for revegetation and restoration in a species rich and still partially known flora is *the benefit of correct provenance is insurance against taxonomic changes* (or more simply, the further away from the site, the more likely are major taxonomic problems). There are numerous examples, but several suffice.

- Australia wide issues: planting of *Casuarina glauca* from eastern Australia in significant wetlands when *C. obesa* was combined into this taxon.
- Regional issues: planting of *Dryandra nivea* (now *Banksia nivea*) in rehabilitation sites when *Dryandra lindleyana* (now *B. dallanneyi*) was the required taxon, before these were separated.
- Local issues: planting of horticultural forms of Geraldton Wax (*Chamelaucium uncinatum*) in Bold Park, or the northern multi-stemmed forms of *Banksia menziesii* on the Freeway; both then hybridising with local native variants.

While the first rule is 'use local seed or propagules to minimise taxonomic issues', how does one know what taxa potentially contain un-named variants in such a diverse flora? Most regional vegetation and flora reports focus on listed rare flora under the *Wildlife Conservation Act 1950* (WA) and the *Environment Protection and Biodiversity Act 1999* (C'th) and WA listed Priority taxa. However our reports (and those of some other authors) use the term 'significant flora' for the rare categories as well as the categories outlined in Table 1.

The categories in the table are becoming an integral part of conservation planning, including that for Perth (Government of Western Australia 2000) and in the current forest management plan for production forests. Using these categories for the Busselton portion of the Plain (Webb *et al*. 2009) gave a total flora of 1387 native species; 91 state Declared Rare Flora (DRF)/Priority listed; 15 local endemics; 159 disjunct; 160 range ends; 189 habitat preferences; and 34 species with significant morphological variation. In the Whicher Scarp (Keighery *et al.* 2008) there were 917 species; 61 state DRF/Priority listed; 40 endemic; 100 disjunct; 81 range ends; 121 habitat preferences; 4 relictual; and 21 significant morphological variation. Currently a whole Plain database is being prepared for publication.

Table 1. Categories developed to encompass as much regional variation as possible within a set of codes suitable for use in data bases.

Geographic location	
r	populations at the northern/southern limit of their known geographic range
d	populations disjunct from their known geographic range
p	considered to be poorly reserved (applies to all Declared Rare Flora and Priority taxa)
s	significant populations in reference to location, population size, diversity of ages and/or health (applies to all Declared Rare Flora and Priority taxa)
u	uncommon in the area (generally applies to disjunct populations)
x	considered lost in the Swan Coastal Plain
Ecological preferences	
e	taxa endemic to the Swan Coastal Plain (or the area/region being considered)
h	taxa distinct habitat preference (wetlands/soil type)
a	relictual taxa
Morphological and/or genetic variation	
v	variant, not at taxonomic level
t	variant, significant taxonomically
g	genetic variant

Conclusion

The above lists flag species that one should be very careful about sourcing propagation material for the Plain. Unfortunately, with such a rich flora and increasing development pressures, waiting for genetic data on provenance and published taxonomic studies is not a feasible option since they will not be available for most species in the foreseeable future.

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Assessing botanical capacity in the United States: gaps identified and strategic recommendations made to maximise conservation success

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Botany is not optional

The botanical community plays a mission-critical role in researching, conserving, and sustainably managing the world's plant diversity and resources. Botanical expertise is required to address current and future grand challenges and issues, including climate change mitigation, land management and wildlife habitat restoration, understanding the provision of ecosystem services, management and control of invasive species, and the conservation and recovery of rare species.

Despite the fundamental role botanical capacity plays in tackling each of these issues, botanical capacity (see Figure 1) appears to be eroding in many sectors of the United States botanical community (government, academic and private). This includes a shortage of botanists at government agencies (likely to be compounded by a predicted wave of retirements), and declines in botanical degree programs and course offerings at the nation's colleges and universities. However, until recently these reported declines were largely anecdotal, out-of-date, or too narrowly focused, and there was a clear need to comprehensively assess botanical capacity in the United States. Without the broad base of information such an assessment provides, it was difficult to fully identify strengths or weaknesses in the botanical community, and nearly impossible to take actions to efficiently and effectively fill critical gaps in capacity.

Assessing botanical capacity in the United States

To begin addressing the need for a comprehensive and up-to-date analysis of the nation's current botanical capacity, an assessment project was initiated in 2009 by the Chicago Botanic Garden, in partnership with Botanic Gardens Conservation International U.S. (with funding from the National Fish and Wildlife Foundation). This project aimed to evaluate the state of botanical capacity as it applies to plant science research, education, and application. As such, its identified stakeholders included scientists, graduate students, administrators, educators and land managers involved in natural resource management, education and research across the United States in government, academic, and private sectors.

An initial search of published and grey literature was carried out to gather and synthesise all available background information available regarding past and current botanical capacity (education, training, research, application, and infrastructure) in the United States. Project staff worked in consultation with members of an established advisory board and other individuals in the botanical community to develop, test, and ultimately carry out seven on-line surveys. This included surveys for 1) federal government agency staff, 2) state natural heritage program staff, 3) other regional, state, county or city government staff, 4) non-profit organisation staff, 5) self-employed and for-profit staff, 6) graduate students (masters- and doctorate-level), and 7) academic faculty staff.

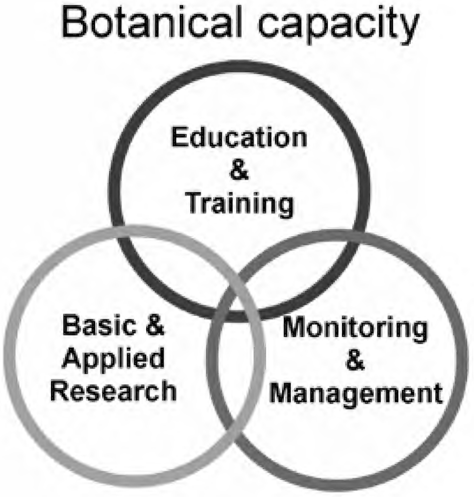

Figure 1. Botanical capacity is the human, scientific, technological, organisational, institutional and resource capabilities that support plant-based education and training, basic and applied research, and monitoring and management.

On-line surveys were open and publicly available during the summer of 2009, with requests for participation sent via print and electronic means. During this time, 1569 individual survey responses were recorded. Following survey closure, a facilitated workshop involving 30 stakeholders from government, academic and private institutions was held at Chicago Botanic Garden in autumn 2009. The purpose of the workshop was to bring professionals from the US botanical community together to discuss the survey results and make recommendations to fill critical gaps in botanical capacity which it identified. Following this, results of the literature search, surveys, and workshop outcomes were synthesised in a full report.

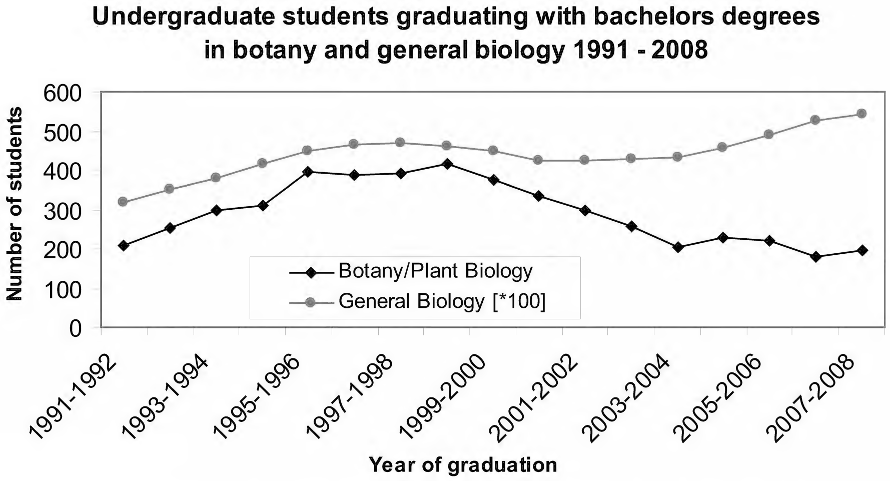

Figure 2. Comparison of undergraduate students graduating with a degree in botany/ plant biology versus a degree in general biology (reported by the National Center for Education Statistics). Note that numbers for general biology graduates are divided by 100 to facilitate viewing on a single graph.

Key report findings

Education and training

Survey respondents reported an inability to find appropriately trained botanists to fill currently open positions within government and non-profit agencies, and they were generally dissatisfied with the botanical training of incoming employees. At the current rate of decline in botany programs at colleges and universities, and as more botanists are needed in the coming decade to fill current gaps in capacity and refill positions following retirement, it is not clear that there will be an appropriately trained workforce to fill vacancies when they are needed most.

Analysis of data from the US National Science Foundation showed that in 1988, 72% of the nation's top 50 most-funded universities offered advanced degree programs in botany. By 2009, more than half of these universities had eliminated their botany programs and many, if not all, related courses. Likewise, data from the US Department of Education from 2000 to 2008 revealed that undergraduate degrees earned in botany declined 50% while degrees awarded in general biology rose nearly 17% (see Figure 2).

Recommendations to fill the increasing gaps in botanical education and training included:

1. better communication between government agencies and universities to ensure students are aware of and able to take botany coursework that they need to be employable,
2. working with accreditation bodies at the national level to ensure that biology programs include strong coursework in plant sciences, and
3. to recognize the growing role non-profit organisations (such as botanic gardens) are playing in teaching courses that have been dropped by universities, such as field botany and invasive species biology.

Research and management

Survey results showed that plants are being left out of climate change planning and action, likely due at least in part to a false perception that plants are not being impacted by climate change. At the research level, survey results showed an unmet demand for research on invasive species. While survey respondents unanimously selected invasive species control as the top management issue requiring additional research, strikingly few faculty or graduate students reported undertaking research that was applicable to invasive species control.

Government agencies currently lack the botanical capacity required to guide efficient and effective management of the nation's most critical biological resources. Survey results document severe shortages of management and research staff with botanical degrees. For example, in response to the question *Do you think your agency has enough botanically trained staff to meet its current management/research needs?* 94% of the 358 respondents in federal government agencies indicated that botany was the top job area with a shortage. These shortages occur throughout all federal and state government agencies, with some of the most significant ones found in agencies directly responsible for managing public lands.

Already critically lacking, botanical expertise at federal agencies will continue to decline over the next 15 years as more than half of the current workforce retires (see Figure 3). Because this decay in botanical infrastructure at government agencies is occurring in tandem with declines in botanical education and training opportunities at the nation's universities, it requires immediate attention. The private sector is filling many gaps in botanical education

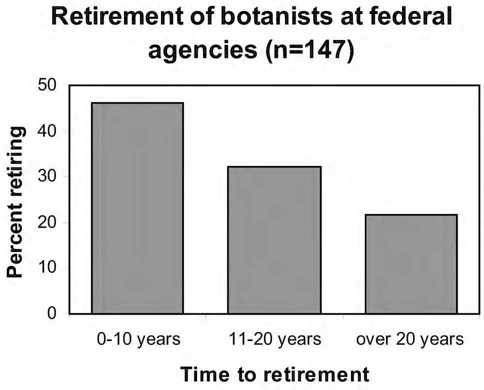

Figure 3. Retirement of survey respondents who are employed as federal botanists. There will be a significant need for a botanically trained workforce to fill the vacancies created by these retirements.

and research, but recommendations were made to ensure more sustainable support and partnerships amongst the academic, private, and government sectors to ensure the private sector is able to continue filling these gaps in the future.

Further information

For full details on this assessment and the results and recommendations that came from it, please visit www.bgci.org/usa/bcap, which contains free pdf copies of the full report (Kramer *et al*. 2010), executive summary, and recommendations.

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A practical genetic contribution towards best-practice seed-sourcing guidelines for ecological restoration

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Introduction

Seed sourcing issues are of fundamental importance for successful ecological restoration. Where biodiversity objectives are a high priority in an ecological restoration project, the sourcing of diverse, local provenance seed has been long recognised as best practice. There are situations where local provenance seed may not be a priority (e.g. restoring highly altered landscapes) and other issues such as source population properties require consideration (Broadhurst *et al*. 2008). However there remain numerous reasons, described below, why local provenance must be considered a starting point for seed sourcing decisions.

Provenance matters

It has been known for more than 300 years that all species display genecological variation throughout their range. Thus, populations of plants are adapted such that their phenotypes respond as well as possible to the environmental factors of their particular habitats. In an ecological restoration context, this has been termed ***home-site advantage***, where local genotypes display greater fitness than non-local genotypes. For example, local (Eneabba) *Banksia prionotes* seed grown in a glasshouse in local (Eneabba) soil displayed seedling biomass and vigour three times that of non-local (Badgingarra) seed (Figure 1). This home-site advantage can result in ineffective and inefficient restoration if using poorly adapted non-local provenance seed.

The introduction of non-local provenance genotypes can have negative genetic effects of poor integration with local genotypes. Mating between non-local and local genotypes can result in ***outbreeding depression*** in their offspring (Hufford and Mazer 2004). Impacts of outbreeding depression can be as severe as negative impacts from inbreeding depression. For example, artificial cross pollinations between *Stylidium hispidum* (triggerplant) plants sourced from populations separated by 120 km resulted in less than half the number of established seedlings compared to crosses between local plants, as a consequence of outbreeding depression.

Poor genetic integration of non-local genotypes can also result in the ***genetic swamping*** of local genotypes. For example, the local variety of *Chamelaucium uncinatum* in Bold Park, Perth, called Wembley Wax, is threatened by genetic swamping caused by the introduction of a cultivated northern variety, the Geraldton Wax. Without the removal of the introduced variety, the loss of the locally significant variety through genetic dilution or swamping is likely.

Through the ***extended phenotype***, genetically differentiated provenances can have a marked effect on the biological communities they support. For example, assessment of a provenance trial in *Eucalyptus globulus* showed different provenances harbour different fungi and arthropod communities (Barbour *et al*. 2009). Sourcing seed from non-local populations can have negative flow-on effects on the biological communities they support.

Biological diversity is recognised through the Convention on Biological Diversity at landscape, ecosystem, species and population genetic levels. Mixing of genetically differentiated provenances leads to an erosion of the natural genetic structure of populations within species, leading to a loss of biodiversity.

How local is local?—a practical genetic contribution

A key question for restoration practitioners, then, is how far from a restoration site can seed be collected before it impacts negatively on restoration outcomes. Negative impacts can be felt through inefficient or ineffective restoration, or through local biodiversity impacts.

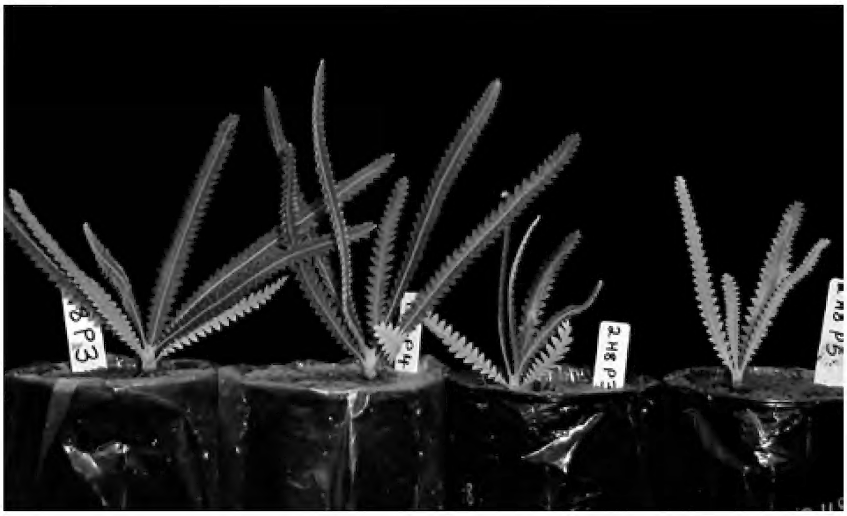

Figure 1. Banksia prionotes *seedlings sourced from plants growing 70 km apart at Eneabba and Badgingarra (south-west Western Australia), grown in soil from the Eneabba site. The relatively poor growth of the non-local Badgingarra seedlings on the right compared to the local Eneabba seedlings on the left, demonstrate a strong home-site advantage for local provenance seeds due to substrate.*

For the past 10 years, we (with support from other research staff, university collaborators, and Australian Research Council and industry funding) have been applying molecular markers and an efficient sampling approach to make a practical genetic contribution to the delineation of local provenance seed collection zones. Whilst the molecular markers we have used are largely neutral, recent reviews indicate that (i) neutral genetic variation estimates of genetic structure are positively correlated with adaptive (quantitative trait) markers, and (ii) genetic structure found with neutral markers typically hides a lot of cryptic genetic differentiation in genes coding quantitative traits (Savolainen *et al*. 2007). That is, neutral markers almost always substantially under-estimate the genetic differentiation among populations found with adaptive markers, further emphasising the importance of local provenance because they are best adapted to local conditions.

In our pursuit of a genetic provenance atlas for south-west Western Australia, we now have population genetic data for more than 35 native plant species (Bussell *et al.* 2006). These data are visualised in two key ways. Firstly, ordinations of all samples show the degree of genetic overlap among populations. Strongly differentiated populations will show no overlap, while undifferentiated populations will show marked overlap. Secondly, we use a measure (Fst) that indicates the proportion of total genetic variation that is partitioned among populations compared to that within populations. A high Fst indicates most variation is partitioned among populations, and the genetic differentiation among populations is strong.

For general utility, we have interpreted these ordination and Fst results and classified species into one of three provenance classes—narrow, intermediate and broad—to guide seed collectors on the relative importance on sourcing seed locally. For example, *Acacia rostellifera* showed very high Fst and marked non-overlap of population clusters in ordinations of genetic data, and was classified as having a narrow genetic provenance, so seed should be collected very locally. At the other scale, wind pollinated Restionaceae and Cyperaceae were found to have very low Fst and marked overlap of populations in ordinations, indicating a broad provenance, with wide seed collection acceptable. The widespread tree species Jarrah (*Eucalyptus marginata*), Marri (*Corymbia calophylla*) and She-oak (*Allocasuarina fraseriana*) were found to have similarly broad provenances for seed sourcing.

Conclusion

Our continuing studies are providing practical genetic seed sourcing guidelines for restoration practitioners, and are re-emphasizing the importance of local provenance seed sourcing where there are biodiversity objectives.

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Unexpected richness of *Wurmbea* species in the Midwest, Murchison and Gascoyne rangelands, Western Australia

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Introduction

Wurmbea is a genus of the family Colchicaceae native to Australia, New Zealand and Africa. Until recently it was considered there were almost equal numbers of species in Africa and Australia, but recent discoveries have altered this picture to c. 50 Australian species, c. 20 in Africa and 1 in New Zealand. The closest relatives of *Wurmbea* are in southern Africa (Vinnersten and Manning 2007).

Wurmbea plants are geophytes that survive summer as underground corms, shooting in autumn (often in response to rain), growing from autumn to spring, and flowering from April to September, depending on the species. The plant structure is remarkably uniform for a genus with relatively numerous species and growing from high rainfall forests and swamps to desert sands. The corm gives rise to a single shoot with almost always three leaves, sometimes two, and a single terminal unbranched inflorescence with from one to over 20 flowers. Each flower has 6-8 perianth parts in one whorl, called tepals. Within this simple structure there are many varying details that enable the species to be distinguished. Leaf number, shape and position, flower sexuality, number, colour, shape, extent of tepal fusion, ovary and style features, and especially the tepal nectaries (whether one or two, their position, colour and shape) all help to characterise species. The flowers are often very attractive.

Wurmbea in Australia

The Australian state with the most species of *Wurmbea* is Western Australia (WA) with 39. South Australia (SA) is also rich with 15 species, whereas New South Wales (NSW), Victoria (Vic) and Tasmania have 4-6 each and Queensland and the Northern Territory have only two each. This reflects the temperate nature of *Wurmbea*. The diversity in WA and SA seems to be related to an association between Colchicaceae and drier climates that has been noted in South Africa, and the richness of habitat variation in temperate parts of WA and the wholly temperate SA. Even so, the relative paucity of species in NSW and Vic is surprising.

Progress in species discovery for Australian *Wurmbea* is indicated by Bentham's *Flora Australiensis* of 1878 containing six species, with no further original taxonomy occurring for a century until the next revision (Macfarlane 1980), which was the basis of the 1987 *Flora of Australia* treatment with 20 species. In the years 1986-2007 a further five species were discovered and described from WA, a common pattern in Australian plant taxonomy where published work stimulates observation and further discovery. In SA in the same period the number of species has increased from four to 11 (Bates 2007) as a result of field observations and collecting, which revealed distinctions not apparent previously when using only meagre herbarium collections. By 2007 the number of named species of *Wurmbea* in Australia stood at 28.

Wurmbea in Western Australia

In Western Australia there has been a tendency to think of *Wurmbea* as a genus of the better-watered parts of the south-west, the coastal, forest and farmed areas. However in recent years increasing observations of plants have occurred in the rangeland areas of the arid zone east and north of the south-western area, which did not match named species. Consequently we embarked on a program to learn more about *Wurmbea* in the rangelands, especially of the Midwest, Murchison and Gascoyne regions. This involved visiting areas at different times of the year to account for different flowering times and different habitats, and included exploration of previously unvisited areas.

Taxonomic puzzles were solved through field work that enabled comparison of habitats and live plants, and included further intensive surveys of selected areas to find additional populations of particular species. Among difficulties encountered have been dry seasons when plants did not flower and seasons when rain came late, changing flowering time by up to a month. Consequently some species have required repeated visits to be caught in flower.

Largely as a result of this field program focussed specifically on *Wurmbea*, the current species tally for WA is 17 formally named species and 22 species that are considered new but have not been formally named and described. Most of these un-named species have been recognised in the last five years, and most occur in the rangelands of the Midwest, Murchison and Gascoyne regions (Figure 1).

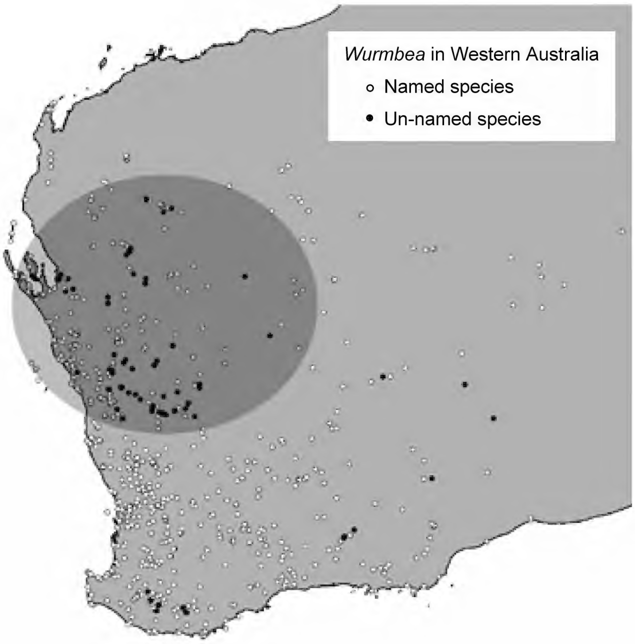

Figure 1. Map showing specimens of named and un-named species of Wurmbea *in Western Australia, illustrating the concentration of new species in the Midwest, Murchison and Gascoyne rangelands (shown by the shaded ellipse).*

New species have been recognised in various circumstances, sometimes fortuitously, e.g. *Wurmbea* sp. Thomas River (A. Case & B. Cole 58), sighted from a vehicle by A. Case, and *Wurmbea* sp. White Wells (T.D. Macfarlane et al. TDM 4345), found at a camp site. Other circumstances include:

- discovery during the search for another *Wurmbea* species, e.g. *Wurmbea* sp. Shark Bay (T.D. Macfarlane et al. TDM 4672) or survey of another genus, *Eremophila*, e.g. *Wurmbea* sp. Upper Murchison (A.P. Brown & J. Start APB 3562);
- separation from inclusion in a different species after field recognition of flowering time differences followed by study of herbarium collections, e.g. *Wurmbea* sp. Paynes Find (C.J. French 1237); and
- planned general floristic surveys (e.g. Banded Ironstone Survey, Carnarvon Basin Survey).

The new rangeland *Wurmbea* species occur in a variety of habitats including eucalypt and *Acacia* woodland, bare rocky hills, semi-saline chenopod shrubland in a claypan; river pool banks; and coastal heath over limestone. Some of these are exceptionally harsh environments (Figure 2).

Conservation

A number of the rangeland species are apparently restricted to special habitats that are themselves uncommon, or to particular ranges of hills or drainage features, whereas others have proven to be abundant and widespread. Consequently whilst some species are not of immediate conservation concern, others are. Some of the threats they may face include grazing by domestic and feral animals, erosion as a result of over-grazing, weed invasion, mining (especially relevant to species limited to particular hills), and climate drying. It is therefore a priority to ensure that all undescribed species are in the short-term given phrase names so that they are on record, and then to formally name and describe them. Continued field work to detail actual distributions of the species and to monitor their condition is also required.

Conclusion

The program of field work aimed specifically at *Wurmbea* has shown unexpected richness of the genus in the rangelands of Western Australia. The limited period of visibility of *Wurmbea* due to its geophytic habit and short autumn to winter flowering period partly explains the failure of previous general collecting to turn up most of these un-named species. However, it is likely that there are a number of other plant groups where specialised attention would reveal unknown species or enable known variation to be explained. Even for *Wurmbea* the exploring is not at all complete and will continue with the valued help of volunteers and, of course, good seasons.

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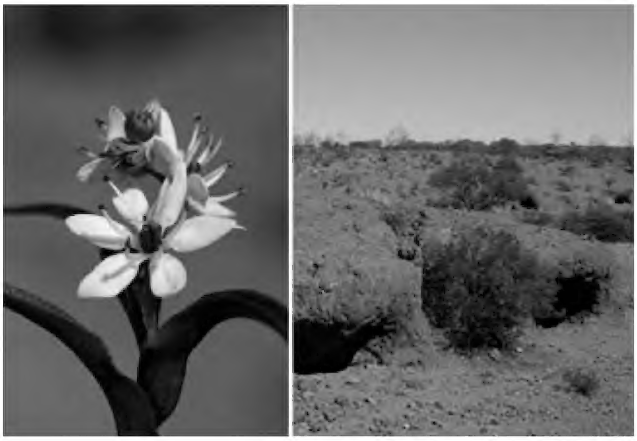

Figure 2. A bare rocky site in the Murchison rangelands (right) where two un-named Wurmbea *species grow, and flowers of one of them (left),* Wurmbea *sp. Boolardy (R. Meissner & G. Owen 1502). Photos: Andrew Brown.*

An interesting plant community of hypo-saline seasonal lakes in the Muir-Unicup catchment, Western Australia

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Introduction

South Western Australia (WA) has a variety of wetlands, ranging from fresh to hypersaline (more saline than sea-water), shallow to deep, and permanent to seasonal water. Wetland plant communities are related to these water body characteristics, geographic location, long term historical factors, and degree of human modification including clearing of natural vegetation locally and in the whole catchment, water draw from streams, rivers and aquifers, and drainage works.

Wetland plant communities in South Western Australia have been described by a number of authors, e.g. Keighery *et al*. (2004) in a major study of the WA agricultural zone. Despite the numerous sites being compared using rigorous numerical analysis, we concluded that their grouping of wetlands in our study area was too coarse to distinguish the insufficiently known plant community of hypo-saline (less saline than sea-water), shallow seasonal lakes that we describe here.

The study wetlands occur in the Muir-Unicup Catchment near Manjimup, a Recovery Catchment under the WA Salinity Action Plan. The topography of the catchment is subdued with poorly defined, largely internal drainage, two large shallow non-permanent lakes—Lake Muir and Lake Unicup—and a variety of wetland types. This study focussed on shallow, seasonal, brackish or hypo-saline lakes.

The lakes and their physical structure

The study lakes are a subset of the wetlands or lakes in the Muir-Unicup catchment. Wetlands we consider to belong to this category and have sampled include the relatively large Little Unicup Lake; 'Branchinella Lake', a small informally named lake south of Lake Unicup; West Tolkerlup Lake, a relatively large lake; and 'Cricket Ground Lake', a medium-sized lake.

The lakes are not all identical in structure and fringing vegetation, but Figure 1 summarises their general features. They are usually associated with old stable sand dunes on one to all sides that are vegetated by *Eucalyptus* or *Melaleuca* trees. They are underlain by layers of water-impeding clays and then by bedrock, and the floor is of white to grey sandy clays that set hard and may crack when dried out. Water is acquired from rain or from seepage from the adjacent sandy rises, or occasionally from rare surface inflow. Usually all the water evaporates when the weather warms, surface outlets or sediments only carrying water from the lake in rare wet times.

Fringing vegetation includes some or all of the following: small trees of *Melaleuca raphiophylla* and *M. cuticularis*; the sedges *Baumea vaginalis* and *B. pressii*; the samphires *Tecticornia* spp. perennial subshrubs *Wilsonia backhousei* and *W. humilis*, and various annual plants. The true aquatics occupy the lake floor proper.

The water qualities of the wetlands are summarised in Table 1, and data for Little Unicup Lake shown in Figure 2.

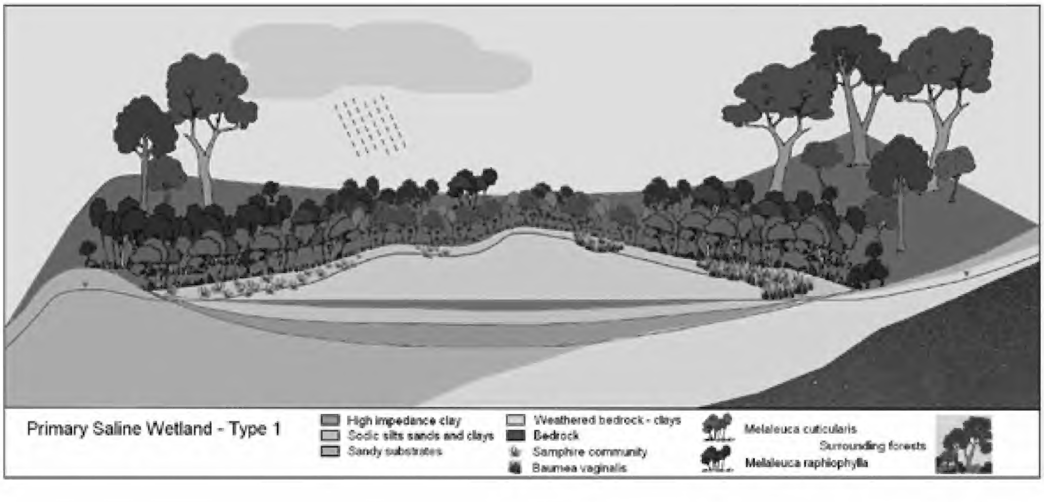

Figure 1. Diagram of the structure of shallow wetlands in the Muir-Unicup catchment. Graphic: R.W. Hearn.

Plant community of the lake floor

A small number of species makes up the community, although not all species are necessarily present in every wetland of the group. The species are the Angiosperms *Ruppia polycarpa* (Sea Tassel), *Lepilaena cylindrocarpa* (Water Mat), *Trithuria austinensis* and *Triglochin mucronata*; the aquatic liverworts *Riella halophila* and *Riella* sp. and the green alga *Lamprothamnium heraldii* (Stonewort). The small number of species suggests that only a few plant groups have developed the capacity to cope with the lakes' very demanding physiological and seasonal conditions. Conversely the individuals of each species are usually extremely abundant.

The species represent a wide range of plant groups, including various families of Angiosperms, Liverworts, which are not often aquatic, and a Charophyte. They include *Trithuria* (Hydatellaceae) a representative of the Basal Angiosperms group, neither Monocot nor Dicot, related to the very different-looking Water Lilies (Nymphaeaceae). The families are familiar in wetlands (especially brackish ones) from around the world, except *Trithuria* which is nearly endemic to Australasia. The diversity of phylogenetic relationships, including some ancient lineages, indicate that these wetland conditions may have existed in south-western WA for a long time, though not necessarily in exactly the same locations as now.

Taxonomic issues were encountered, including confusion about the species present for some genera due to doubtful, possibly out-dated, past records. *Trithuria austinensis* was undescribed at the outset; *Riella* had not been recorded for WA previously and one of the two species is apparently un-named. Charophyte identification is almost impossible in WA, but we thank Michelle Casanova for suggesting a name.

Table 1. Water qualities of the Muir-Unicup wetlands.

Depth	• quite shallow: maximum depth of different lakes varies; extremes of the range are from extremely shallow (approx. 20-30 cm) to moderately shallow (up to 1 m) • water persists continuously for an extended period in most years • water bodies can be quite large so they provide substantial habitat space
Temperature	• the warming trend over each season is consistent with the shallow water body tracking ambient temperature • sharp warming at the end of the season as water depth falls
Salinity	• low to moderate salinity for most of the season, e.g. Little Unicup: 15-20% seawater, Branchinella: 8-10% seawater • initially very fresh, soon reaching the seasonal norm • rapid rise in salinity late in the season due to evaporation
pH	• all lakes are usually slightly to strongly alkaline, sometimes becoming slightly acid

Notable biological features of the species include that all are annuals; most are dioecious (separate male and female plants), which is uncommon in plants overall; and the modes of fertilisation present include within-water, at water surface, and by wind, but no insect pollination.

The community in context

Similar communities are known from elsewhere in Australia and the world, for example in the Mediterranean region. However the Muir-Unicup wetlands have a unique set of species, adapted to the seasonal pattern and water conditions, and related to history of the biota. Whilst the families and genera are mostly represented elsewhere, these species include Australian and WA endemics, indicating a regionally evolved component. The lack of non-native species (weeds) supports the assumption that the plants in these wetlands have been little affected by environmental changes due to human activity.

Conservation

The special character of the Muir-Unicup wetlands plant species calls for their recognition as a separate plant community so that it may be given appropriate conservation consideration. Other organisms are also involved, such as invertebrates and water birds which derive food from the plants. Wetland environments may be stable but are of limited extent and number, so they are vulnerable to deleterious environmental effects. The latter include change in salinity, drainage works, acid ground water, prolonged drought beyond historical norms (particularly reduced length of wetting per year), physical disturbance to lake and margins and clearing of neighbourhood native vegetation. Currently the situation is reasonably positive given that the wetlands are mostly on reserve land, are embedded in native vegetation, and are mostly isolated from water courses that could bring deleterious outside effects. However some of the threats are real and require vigilance.

Conclusion

Climate change projections indicate that the Muir-Unicup catchment is in a drying area, with the south-west corner of Australia expected to have a greater reduction in rainfall than many other parts of the continent. One issue this raises is whether the drying will have an adverse impact on these wetland communities. Another is that, since the wetlands are essentially pristine, they should have a role as standards against which to compare current conditions and long-term environmental changes in other wetlands, particularly in the WA agricultural zone.

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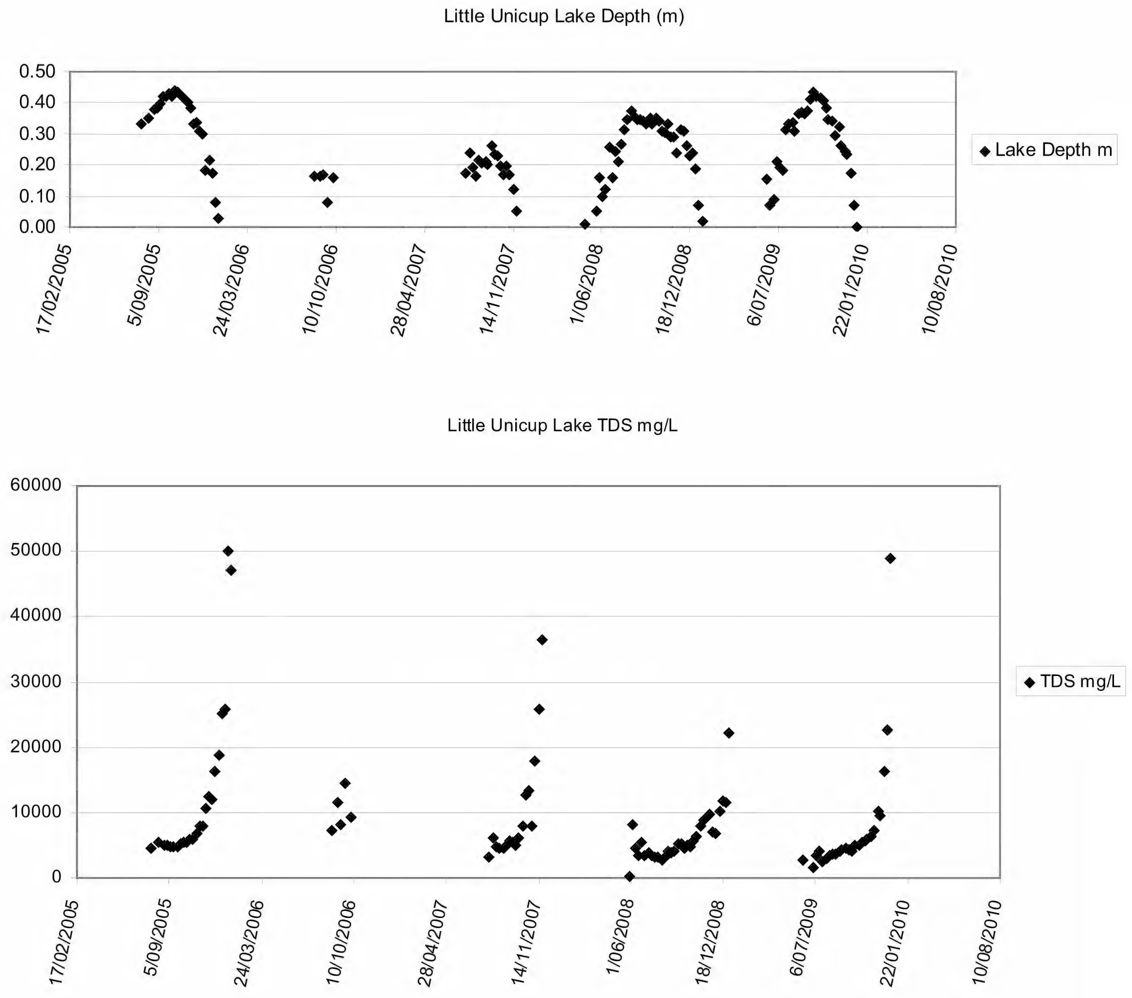

Figure 2. Some physical and chemical water characteristics for Little Unicup Lake, an example shallow hypo-saline lake in the Muir-Unicup Catchment based on five years of sampling. Graphic: R.W. Hearn.

Engaging with industry in plant conservation—state of play in 2010

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Role of industry in plant conservation investigations

The role of industry groups has altered in the last few decades as a result of a growing interest in the environment, the interconnectivity between people and the environment and potentially the increasing pressures that human activities have also placed on the environment.

If one reviews the earlier role of industry, there was an initial attitude of doing biological studies to list what plants were present in a particular area. This initial early work was based on a more historical naturalist approach (see Table 1). As the concepts of ecological research developed and community interests increased, basic flora lists have been replaced by complex reporting mechanisms on not only what flora values are present (Table 1), but also where they occur, why they occur where they do, and what their role is in the ecological processes operating in the respective areas. The complexity of investigations has also expanded to include genetic, species and ecosystem investigations.

In many ways the latter shift has occurred as a result of increasing pressures from human activities as well as increasing human expectations on standards in relation to environmental assessments and intergenerational equity issues on our natural resources.

Industry groups have a range of key roles to play in plant conservation areas. This is in part driven by a range of key initial factors including investigation needs from both a legal and non-legal perspective, and the increasing community expectations related to biodiversity at the local, regional, state, federal and international scales. As indicated by recent industry reviews this involvement occurs at many different phases of an operation from early exploration, development, post development, and rehabilitation to closure (ICMM 2006).

The types of work undertaken by industry include:

- planning survey efforts to maximise the return for effort by undertaking work in appropriate seasons;
- defining flora values, including collection, identification and submission of specimens into state herbaria;
- provision of critical local and regional data for interpretation and assessment of values;
- understanding the biology of species to assist in designing and implementing rehabilitation programs after operational activities;
- reviewing the significance of these values in a local, regional, national and international context;
- undertaking followup work on a particular species or type as a result of lack of data and knowledge;
- developing and funding research programs on specific species or areas of interest;
- expanding assessments to include analogue or reference sites (often outside any proposed development areas); and
- the potential need to assess impacts of a particular proposed development, particularly in the more formal environmental assessment processes at the state and federal levels.

In many areas of Australia, the efforts undertaken by industry groups may be in areas not assessed or surveyed previously. Furthermore the efforts may be aligned with regional studies being undertaken by key research teams and research organisations. In the latter cases the activities are facilitated by a range of teams working in the same area, with consequential benefits to our understanding of the natural resources and in particular the flora species.

Engaging with industry groups

The engagement of researchers with industry groups has increased in recent decades. An example of this engagement leading to improved information on plant species is the improved understanding of issues associated with *Conospermum toddii* and some associated priority species on the Yellow Sandplain communities east of Kalgoorlie (Murdock *et al*. 2010). These studies have been undertaken in close collaboration with regional staff of the Department of Environment and Conservation and several mining companies including Energy and Minerals Australia and Tropicana Joint Venture. This example exemplifies the trend of some projects to engage experienced botanists and researchers in addressing the issues in the early phases of the proposed developments. This shift in attitudes within industry has led to many benefits not only on the latter project at Mulga Rocks, but also in a wide range of similar projects, many of which do not support rare or priority species.

Scott Reiffer (Mattiske Consulting Pty Ltd) collecting flora data as part of a mining project in Western Australia. Photo: N. Murdock.

The quality of the engagement required in these relationships is critical to the eventual clarity on the delineation of the plant conservation values through the assessment processes. By implementing a risk analysis approach to such an arrangement the likelihood of disagreement on outcomes is generally avoided. In most instances, such an engagement can lead to a better interpretation of what flora values occur and how these can be managed.

There is no doubt that increasing legal requirements for undertaking comprehensive, adequate and representative surveys has assisted in the changes that have occurred, however in many instances research undertaken is not necessarily driven by development. Without industry and independent consultants many of these issues would not have been clarified and the regulators would have been in more difficult positions in terms of determining environmental outcomes.

Co-operation between mining companies, government departments and environmental agencies may assist in clarifying the conservation status of native flora.

Summary

Industry and associated consulting groups have played an increasing role in plant conservation within Australia including Western Australia. Historically, many research efforts have been undertaken by individuals either in their own right or through established academic and research institutions. Since the development of environmental assessments there has been a growing emphasis on encouraging developers and operators to understand what values are in a particular area and what impacts any developments may have on those values. Over the last 30 years the effort exerted by industry groups through their consultants has expanded rapidly from observations on what species and communities may be present to complex interpretations on the range of biodiversity values (genetic to species to communities to ecosystems) and the role of plants in ecosystem services. The benefits of the latter efforts have resulted in a marked improvement in the definition of our biological and natural resources in Western Australia.

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Table 1. Summary of increasing needs on flora data.

Flora data types	1970s	1980s	1990s	2000s	2010s
Flora lists	+	+	+	+	+
Vouchering	+	+	+	+	+
Rare and Priority species	+	+	+	+	Recording numbers
Lifeforms				+	+
Range extensions	+	+	+	+	Recording numbers
Optimal seasonal sampling			+	+	+
Multiple seasonal sampling			+	+	+
Targeted sampling (Rare and Priority)			+	+	+

Australian Myrtaceae threatened by Myrtle Rust

Myrtle Rust, a disease from South America that affects plants in the family Myrtaceae, was first recorded in Australia in a nursery on the New South Wales Central Coast in April 2010. It has since spread via movement of infected plants and has been reported in horticultural situations from Ulladulla to the mid North Coast of NSW. As at 24 December 2010, it had been recorded on 29 species in the Myrtaceae, including species of *Acmena, Backhousia, Callistemon, Eucalyptus, Leptospermum, Melaleuca, Rhodemnia, Rhodomyrtus, Syzygium*, *Tristania* and *Xanthostemon*. Most species affected so far have been from residential properties or nurseries, but by 24 December it had also been confirmed in 25 bushland sites on the Central Coast and is infecting several species in the wild.

Further background information about Myrtle Rust and its threat to biodiversity in Australia can be found on the ANPC website at <http://www.anbg.gov.au/anpc/resources/Myrtle_Rust.html>, and in a Preliminary Determination as a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995*, at <http://www.environment.nsw.gov.au/determinations/exoticrustPD.htm>.

Industry and the public are asked to learn how to recognise the fungus and report any suspected cases early, as well as practise good hygiene methods to restrict its spread. Photos of the rust, fact sheets on its identification and appropriate hygiene measures can be found at <http://www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust>.

Weekly updates on the spread of Myrtle Rust and species it is affecting are provided at <http://www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust/update>.

Training courses in Myrtle Rust identification and bio-sanitation

The ANPC is working to develop an accredited one-day training course for the field recognition and reporting of Myrtle Rust, and for field bio-sanitation. Register your interest in having this course run in your area by contacting ANPC at anpc@anpc.asn.au with subject line ‘Myrtle Rust course EOI’, or ring us on 02 6250 9509.

Searching for *Conospermum toddii* in the Great Victoria Desert, Western Australia

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The Desert

Hidden amongst the yellow sand dune systems of the Great Victoria Desert in Western Australia, grows the Victoria Desert Smokebush (*Conospermum toddii*), a plant that until recently was listed under state legislation as Declared Rare Flora. The Great Victoria Desert is a relatively untouched and floristically diverse area, characterised by extensive longitudinal sand dune and sand plain systems. These systems support a mosaic of eucalypt woodlands and mixed shrub communities that consistently contain Marble Gum (*Eucalyptus gongylocarpa*) over Spinifex (*Triodia* spp.). Energy and Minerals Australia's (EAMA) Mulga Rock Deposit lies approximately 250 km north-east of Kalgoorlie, where extensive vegetation mapping and floristic surveys have been conducted by Mattiske Consulting Pty Ltd since 2007.

Victoria Desert Smokebush is a member of the Proteaceae family and is endemic to Western Australia. It is described as a spreading shrub from 100-200 cm tall that produces white to yellow flowers from July to October. This species is commonly found in and around EAMA's Mulga Rock Deposit area. In 2008 there were estimated to be 6500 mature plants on yellow sand dunes within an area between Queen Victoria Springs Nature Reserve and Plumridge Lakes Nature Reserve (Threatened Species Scientific Committee 2008).

*Victoria Desert Smokebush (*Conospermum toddii*) in flower. Photo: Natalie Murdock.*

Search for Smokebush

The Victoria Desert Smokebush is known to occur on yellow sand dunes, but the size and extent of its numbers had been relatively unknown until recently. Intensive ground searches for the species carried out on the areas surrounding the Mulga Rock Deposit found that it occurs on the dune crests, associated dune shoulders, swale areas between dunes and on transitional sand sheets.

The objectives of this study were to conduct a regional survey of yellow sand dune systems for the presence of Victoria Desert Smokebush. Research priorities outlined in conservation advice from the Threatened Species Scientific Committee (2008) included to:

- assess population size, distribution, ecological requirements and the relative impacts of threatening processes (wild fires, grazing and mining); and
- undertake survey work in suitable habitat and potential habitats to locate any additional populations/ occurrences/remnants.

A Terrain Predictive Model analysing the style, colour and morphology of individual dune systems for predicting the site preferences of the Smokebush was developed by EAMA Consultant Colin Woolard. This was used to select sites up to 100 km from the Mulga Rock Deposit that had the potential to support large Smokebush populations. Because of the remoteness of site, large survey area and difficult sand dune terrain, Mattiske Consulting botanists utilised helicopters in November 2009 and March 2010 to gain unfettered access to the selected dune systems. These sites were flown over and then landed on if a large population of Smokebush was observed from the air. The number of Smokebush plants were counted in a 20 m wide transect running along the dune crest.

Flying high

Populations of Victoria Desert Smokebush were recorded at 38 helicopter sites located up to 70 km from the Mulga Rock Deposit. An estimated 20,000 plants have been recorded at these sites and over 27,000 plants are currently known from Mattiske Consulting, Department of Environment and Conservation and AngloGold Ashanti Australia survey efforts in the Great Victoria Desert. The largest populations of Victoria Desert Smokebush were located on complex sand dunes where two dunes would meet to form a large 'Y'-shaped dune system.

The survey also revealed large populations of Victoria Desert Smokebush, including high proportions of juvenile plants (up to approximately 75% at some sites) on yellow dunes that have been intensively burnt in fires as recent as December 2007. This suggests a re-seeding survival strategy. Fire may only be a major threat to the Victoria Desert Smokebush if intense fires occur more frequently than the interval required for plants to reach maturity and add to the seed bank.

The helicopter surveys by Mattiske Consulting Pty Ltd have also provided additional records for five priority species[1] known to occur around the Mulga Rock Deposit area, and a further four priority species have been recorded through ground surveys. These species are *Dampiera eriantha* (P1), *Hibbertia crispula* (P1 and Vulnerable), *Malleostemon* sp. Officer Basin (D. Pearson 350) (P2), *Dicrastylis cundeeleensis* (P4), *Comesperma viscidulum* (P4), *Grevillea secunda* (P4), *Olearia arida* (P4), *Labichea eremaea* (P3) and *Ptilotus blackii* (P3).

Surveying has also increased the known population numbers of other flora including *Lepidobolus deserti*, *Microcorys macredieana*, *Micromyrtus stenocalyx* and *Baeckea* sp. Great Victoria Desert (A.S. Weston 14813). These species were all removed from Western Australia's Priority Flora list in early 2010.

Priority Ecological Community

The 'Yellow sandplain communities of the Great Victoria Desert' is listed as a Priority 3(ii) Ecological Community[2] that contains very diverse mammalian and reptile fauna, with distinctive plant communities and has threats from mining activities. Surveys by botanists suggest that the vegetation community of the yellow sand dunes may resemble this Priority Ecological Community, having a high species richness and number of Priority flora. The interpretation on the alignment with this ecological community is difficult as little regional or detailed data is available from the Department of Environment and Conservation (2010).

The yellow sand dune vegetation community has been defined as a low shrubland of *Thryptomene biseriata*, *Allocasuarina spinosissima*, *Jacksonia arida*, *Calothamnus gilesii*, *Acacia fragilis*, *Conospermum toddii*, *Pityrodia lepidota*, *Lomandra leucocephala*, *Anthotroche pannosa* and mixed low shrubs over *Triodia desertorum* with *Lepidobolus deserti* and occasional emergent *Eucalyptus* spp (Mattiske Consulting Pty Ltd 2010). The Victoria Desert Smokebush commonly occurs in this yellow sand dune community.

Survey outcomes

Helicopter assisted surveys have confirmed the wide distribution of Victoria Desert Smokebush in the south-western corner of the Great Victoria Desert. It has also been demonstrated that it is possible to predict its occurrence, based on the Terrain Predictive Model, on both recently burnt and unburnt yellow sand dune systems. Little information is known about the Priority Ecological Community and this survey has provided important new information about the occurrence of yellow sand dune communities in the Great Victoria Desert and the associated flora.

Mattiske Consulting botanists Tristan Sleigh and Robyn Chesney on a recently burnt yellow sand dune. Photo: Natalie Murdock.

Victoria Desert Smokebush has been recorded on dune crests, associated dune shoulders, swale areas between dunes and on transitional sand sheets. Since the surveying, the conservation status of Victoria Desert Smokebush has been lowered under state legislation from Declared Rare Flora to Priority 4. Currently, this Smokebush is still listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The helicopter surveys also assisted in clarifying the extent of other Priority flora that occur in and around EAMA's Mulga Rock Deposit.

Co-operation between mining companies, government departments and environmental agencies has therefore resulted in knowledge that has been simultaneously beneficial for the conservation of native flora and for mining exploration activities.

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[1] For definitions of Priority flora categories, see <http://florabase.dec.wa.gov.au/conservationtaxa>.

[2] For definitions of Priority Ecological Communities, see <http://www.dec.wa.gov.au/content/view/849/2017/>.

Ecological, economic and social challenges, restoration filters and planning for the unknown

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Introduction

Since European settlement, large areas of public lands in Australia have been degraded by various anthropogenic disturbances. An example is the Ludlow Tuart Forest (2049 ha), located approximately 200 km south of Perth in Western Australia. This forest is also representative of many of the Tuart (*Eucalyptus gomphocephala*) forests and woodlands in the region, which were logged in the nineteenth and early twentieth century, subject to cattle grazing since the early 1900s and to mining since the early 2000s. These, and other threatening processes have led to invasion by non-endemic species such as Arum Lily (*Zantedeschia aethiopica*) and Annual Veldt Grass (*Ehrharta longifolia*), poor levels of Tuart recruitment, and low levels of understorey diversity and abundance (DEC 2007).

This large-scale degradation has led to a growing desire from the community, conservationists, scientists and land managers to develop techniques to restore public lands such as the Ludlow Tuart Forest. However, restoration faces some interesting challenges, many of which can be explained though ecological, economic and social challenges.

Restoration at Ludlow

Restoration within the Ludlow Tuart Forest is now in its fourth year. The first year began with small scale restoration trials (Ruthrof *et al.* 2010) and has now expanded to restoration of 10–20 ha per annum with simultaneous restoration research trials being embedded within the broadscale restoration to inform and drive the following year of restoration activities. This adaptive, integrated and evidence-based process has been both rewarding and successful and has progressively and steadily increased our understanding of the system and methods of increasing the success of restoration in degraded forest areas. Even so, we have encountered a range of challenges during this time.

Ecological and economic challenges

Ecological challenges encountered in broadscale restoration include the availability of propagules, the ability to germinate a large range of species, control techniques for invasive species (pre- and post-restoration), and choice of species (functional types, keystone species, faunal requirements, palatability and competitive ability). There are also the emerging challenges of a reduction in rainfall, higher temperatures, and perhaps a higher risk of frost.

Lack of available propagules is one of the major hurdles that many restoration programs face. For example, in 2007 when work began in Ludlow, enough seed was available from only six species at the time. This, however, was seen as an opportunity to establish a trial to inform the broader-scale restoration the following year. We continued embedding a restoration trial within the broadscale restoration every year to continually increase our understanding of the system and restoration techniques that would be more successful in terms of establishment and growth. Such ecological challenges are technical constraints, and although significant, are only part of the problem (Geist and Galatowitsch 1999).

Financial resources made available for restoration are often quite limited. Therefore, expensive machinery or propagules (e.g. some species can reach prices of $4/gm) may be out of reach of some projects. The longer term significance of some species—the use of cheap annual species versus more expensive perennials—is also important, and the restorationists must determine the best long-term ecological ‘bang for your buck’. In the case of the Ludlow Tuart Forest, the restoration project had access to off-set funding from mining activities within the adjacent State Forest. Most public lands, however, do not have access to such funds, and is difficult to undertake even small-scale restoration there.

Given these ecological and economic challenges, the resultant vegetation community may be very different from the one practitioners had in mind at the planning stages of the project. For example, the ideal plant species list we started with for Ludlow (approximately 200 species collated from local lists and reference sites) has been reduced to the ones we can acquire and afford, that are resilient (i.e. can compete with the high weed loads), and that have multiple functional and structural characteristics.

Social challenges

Restoration projects face an additional array of social-political challenges. These include which site will be restored, the goals and values for that site, the amount of community support, personal preferences, and the amount of time and labour available to the project, especially in the long term. These are primarily human challenges, and unless overcome, ongoing commitment from land managers, practitioners and the community to restoration projects will likely be limited and it will not be possible to undertake larger scale restoration on public lands.

The community is often seen as a group of individuals for use as cheap labour. However, commitment to, and success of, restoration projects could be increased by development of a beneficial relationship between humans and the natural environment (Geist and Galatowitsch 1999). There are various benefits of community involvement in restoration, including the involvement of hard working, enthusiastic people with a depth of local knowledge, experience and a sense of stewardship that can drive the sustained support for restoration. Benefits of restoration to the community are also broad-ranging and include restoring community spirit and improving agency-community relations (Ryan and Hamin 2008) as well as providing psychological and physiological benefits (Geist and Galatowitsch 1999).

A number of community groups are involved in restoration at Ludlow (Figure 1). However we believe this could be expanded to include higher levels of involvement in all aspects of restoration, given that there is a large amount of local knowledge, enthusiasm and on-going commitment that would be beneficial to restoration planning and implementation.

Reciprocal restoration model

The beneficial relationship between humans and restoration activities is often overlooked. Geist and Galtowitsch (1999) state that the ecological needs of the restoration area have the greatest potential to be met when human contributions are greatest and humans benefit increasingly as the restored ecosystem recovers (Figure 2). Humans contribute to restoration (C1 in Figure 2) through, for example, ecological knowledge, which provides for the needs of the restoration area (N1). This depends on the level of community support of the restoration project (filter) that itself can contribute, for example, to physiological and psychological benefits for humans (C2) which contribute to their needs (N2).

Restoration projects, particularly on public lands, may be more successful in the long term when the community, restoration ecologists, managers and practitioners create an evolving restoration plan together. Perhaps working together in the early stages of planning a restoration project will enhance the filter (Figure 2) for the benefit of both the restoration area and the community involved.

Conclusions

There is an array of ecological and economic challenges to ecological restoration; they are technical constraints and only part of the problem. Social challenges also need to be overcome for increased community involvement in restoration. The community needs to be seen much more than just cheap labour. The reciprocal ecosystem restoration model clearly shows the beneficial relationship between humans and restoration activities. Restoration planning for an uncertain future may benefit from working on restoration plans together. Without joint restoration planning, large-scale restoration of public lands may not be possible.

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Ruthrof, K.X., Douglas, T.K., Calver, M., Barber, P., Dell, B. and Hardy, G. (2010). Restoration treatments improve seedling establishment in a degraded Mediterranean-type *Eucalyptus* ecosystem. *Australian Journal of Botany* 58: 646–55.

Ryan, R.L. and Hamin, E. (2008). Wildfires, communities, and agencies: stakeholders' perceptions of postfire forest restoration and rehabilitation. *Journal of Forestry* 106: 370–9.

Figure 1. Volunteers from the Friends of Island Point assisting with restoration trials in the Ludlow Tuart Forest. Photo: K. Ruthrof.

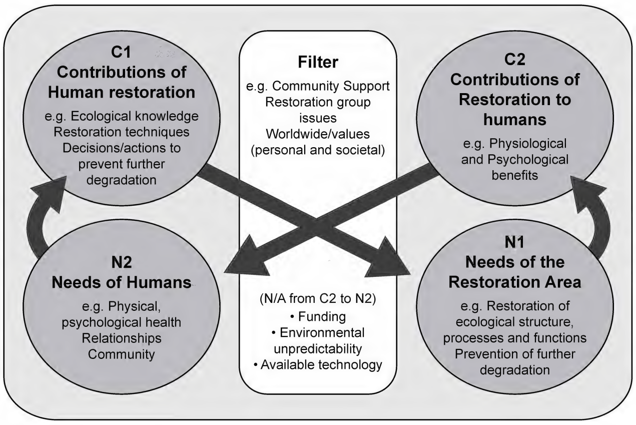
C1
Contributions of Human restoration
e.g. Ecological knowledge
Restoration techniques
Decisions/actions to prevent further degradation
Filter
e.g. Community Support
Restoration group issues
Worldwide/values (personal and societal)
C2
Contributions of Restoration to humans
e.g. Physiological and Psychological benefits
N2
Needs of Humans
e.g. Physical, psychological health
Relationships
Community
(N/A from C2 to N2)
• Funding
• Environmental unpredictability
• Available technology
N1
Needs of the Restoration Area
e.g. Restoration of ecological structure, processes and functions
Prevention of further degradation

Figure 2. The reciprocal ecosystem restoration model. The filter components may act as either constraints or enhancers in the restoration process (after Geist and Galatowitsch 1999).

Fire responses of threatened flora in Western Australia

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Introduction

Western Australia has a large number of threatened and priority flora taxa, representing a wide range of families, with many different strategies for surviving natural disturbances, including fire, which may kill or damage adult plants. The response of different species to fire may depend on the particular fire regime, including fire intensity, seasonality, frequency and extent and can vary within and between populations. Different fire regimes influence not only the survival of a species but also the structure and composition of the surrounding vegetation.

The fire response of many common flora species in the south-western forests of Western Australia has been documented (Burrows *et al*. 2008), but the response of most threatened flora to fire is poorly known and this has hampered their management. This study aimed to collate and analyse the monitoring data for threatened flora populations in Western Australia that have been burnt to determine their fire response category. Information will be used to develop fire management guidelines for individual threatened species and for the general fire response categories identified.

Population data

Data were collated from a variety of sources including population monitoring data from the Department of Environment and Conservation's (DEC) threatened flora corporate database, district records, recruitment burns, published information, WA Herbarium records and personal observations. Fire history data were also accessed from GIS analysis by the Fire Management Services division of DEC.

The study area covers all of Western Australia except the Pilbara and Kimberley regions in the north of the state. The quality of the data varied due to the monitoring effort and the remoteness of many populations. Recruitment burns of individual threatened flora plants and quadrat monitoring after prescribed burning and wildfires provided the most accurate fire response data.

Broad fire response categories were based on the ability of plants to regenerate after fire by re-seeding (S), re-sprouting (R) or both (RS, Rs or Sr—see Figure 1 caption). The age to first flowering, or juvenile period, was recorded when most regenerating plants (>50%) in a population had some flowers (Burrows *et al*. 2008) although this was not always clear from monitoring records. Populations were also assessed on their ability to respond to other disturbance events, particularly soil disturbance, where this had been observed. Data for several populations were compared and an assessment made on the most common fire response for each threatened taxon.

Re-seeders or re-sprouters?

There were 393 threatened flora taxa covering 34 families gazetted in Western Australia by DEC in April 2010. Of the 249 taxa with some fire response data, 51% responded to fire by re-seeding, 20% responded by re-sprouting, 27% responded by re-seeding and re-sprouting, 2% of taxa had been burnt but had not regenerated, and 115 taxa had no fire response records (Figure 1). Ninety six taxa, including

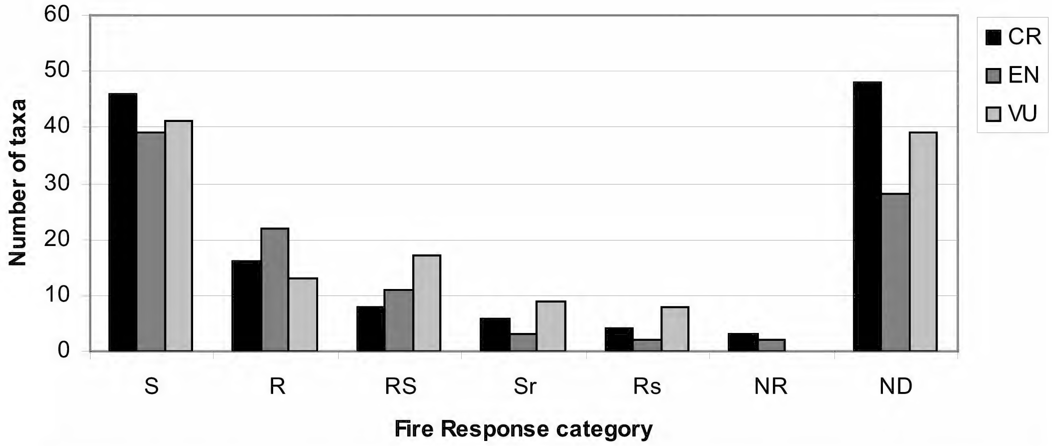

Figure 1. Fire response categories of threatened flora in Western Australia. Categories include S: re-seeder, R: re-sprouter, RS: re-seeder/re-sprouter, Sr: mainly re-seeder but can re-sprout, Rs: mainly re-sprouter but can re-seed, NR: no response observed after fire, ND: no data recorded. Taxa have been separated into the IUCN conservation codes CR: critically endangered, EN: endangered and VU: vulnerable.

44 in Fabaceae, were recorded as having responded to soil disturbance by re-seeding and were classed as disturbance opportunists.

The juvenile periods and minimum fire intervals were recorded for 162 taxa. Thirty taxa had minimum fire intervals <3 years but these were mostly re-sprouter species, including many orchids. Seventy five taxa required a minimum fire interval of 3-8 years, while 57 taxa required minimum fire intervals >8 years. The age to first flowering is unknown for a large number of threatened taxa, including 110 taxa that have fire records.

Future work and implications

Increased monitoring effort is required to capture the fire response of threatened taxa in different populations after fire. The age to first flowering, reliable fruit set and senescence are essential life attributes for determining appropriate fire intervals. More research is required into dormancy and viability aspects of the soil-stored seed bank and the effect of fire season on successful recruitment in semi-arid areas. Recruitment burn trials and regular quadrat monitoring before and after fire are invaluable tools for capturing the data required. Fire management guidelines are being developed for a number of threatened taxa based on the data collated from this project.

This project has highlighted the fact that many of our threatened taxa are re-seeders and disturbance opportunist species that require some disturbance, either fire or soil disturbance, to regenerate. By protecting them from these disturbances we may be limiting their opportunities for long-term survival.

Reference

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Recruitment burn of a critically endangered species Cyphanthera odgersii *subsp.* occidentalis. *Photo: Joel Collins.*

Update on Seed Accreditation Project in Western Australia

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Background

The Revegetation Industry Association of WA Inc. (the Association) was set up in 2002 with the following objectives:

- To develop, improve and promote best practice standards for all aspects of revegetation.
- To develop and facilitate training and accreditation systems for the revegetation industry.
- To promote the interests of the association and its members.
- To promote reputable conduct by members.
- To educate practitioners, clients and regulatory authorities in matters of professional interest.
- To promote informed debate about revegetation matters and procedures.

- To educate practitioners, clients and regulatory authorities in matters of professional interest.
- To promote informed debate about revegetation matters and procedures.
- To promote social and professional contact between members.

The Seed Accreditation Project

The Association commenced a Seed Accreditation Project in January 2010 aimed at improving seed collection standards and hence seed quality to achieve better revegetation outcomes and improved professionalism among those involved in the seed industry in Western Australia.

Industry standards now

The seed industry is self-regulating apart from the issuing of collection licenses by the Department of Environment and Conservation under its responsibilities according to the *Wildlife Conservation Act 1950* (WA). In this sense there is a lack of information for end users and generally for many technical aspects of the seed industry covering collection, processing and storage.

Many questions are relevant to the industry processes, including:

- What are appropriate methods for collection of individual species?
- How are seed batches labeled?
- What provenance detail is available?
- Is record keeping adequate?
- Is a data base able to provide useable stock lists?
- How is seed packaged?
- What environmental conditions is the seed stored under?
- Do the storage regimes match the anticipated length of storage?
- Are storage records kept?
- Are appropriate vermin control procedures in place?

Seed accreditation—progress so far

A subcommittee was formed to gather information for six months, and an Accreditation Officer has been appointed to develop and run the project. A workshop and meetings have been held with committee and industry experts.

The future schedule of activities includes:

- continuing development of material to describe standards
- design of a draft plan to be loaded onto the Association's web site
- an industry comment period
- assessment and production of final accreditation documentation
- project launch workshop for industry stakeholders, and
- launch of the formal process.

The Association aims to complete the project in mid to late 2011.

Botanic gardens partnership to help conserve threatened species

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The Australian National Botanic Gardens (ANBG) located in Canberra was the first botanic gardens in Australia to focus exclusively on the cultivation of Australian native plants, including plants threatened with extinction in the wild. Within its mission *to grow, study and promote Australian plants*, it is currently upgrading its plant conservation work.

Gladstone Tondoon Botanic Gardens (Tondoon) maintains a scientific collection from two main areas, that of the Port Curtis Region and Far North Queensland, as part of a conservation strategy to ensure that the nation's environmental heritage is passed on to future generations.

Conservation partnership

At the 2009 Botanic Gardens of Australia and New Zealand Congress in Mackay, Queensland, Brent Braddick (Curator of Tondoon) and myself (senior horticulturalist responsible for the rainforest collection at ANBG) discussed the possible role ANBG might be able to play in helping conserve the rare and endangered flora of the Port Curtis Region as part of a dispersed 'national collection'.

Tondoon holds significant collections of threatened species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and

Parsonsia larcomensis*, a Vulnerable vine species found at only a few locations in Coastal Central Queensland. Photo: Brent Braddick.*

the Queensland *Nature Conservation Act 1992* as well as flora that are components of the endangered Brigalow, Semi-evergreen Vine Thicket and Littoral Rainforest ecological communities listed under the EPBC Act. Tondoon also holds collections of species from potential climate change threatened refugia such as the high altitude Kroombit Tops and Granite Creek rainforests. These collections at Tondoon constitute a major resource for ANBG's conservation work.

To supplement wild collection trips, ANBG is developing mutually beneficial partnerships with locally based on-ground practitioners. To this end, letters have been exchanged between the two institutions to share genetic material. In reality this will mean Tondoon providing ANBG with wild collected, vouchered material from the rich flora of the Port Curtis bioregion. This material will be utilised for propagation and/or seed storage and onward distribution to other interested botanic gardens/plant conservation bodies. It can also be distributed back to the Gladstone region for recovery planning and revegetation activities.

Template for other partnerships

It is hoped that this relationship with Tondoon may act as a possible template for the development of similar arrangements with other regional botanic garden. While supplying ANBG with genetic material, these gardens are provided with ANBG's coordinating support in pursuit of a dispersed 'national collection', particularly through the development of the national seed banking initiative. Such relationships can further conservation objectives through spreading risk by making this material available through a national seed bank to other like-minded organisations. However it is important that the benefits flow both ways, especially for the smaller institutions. To this end, ANBG is investigating the possibility of offering professional development opportunities to staff of potential partner organisations, including in its areas of strength such as bioinformatics.

Acknowledgement

My thanks to Brent Braddick, Toondoon Botanic Garden, for his assistance in preparing this paper.

Report from New Zealand Plant Conservation Network

Danielle Hancock

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Website changes—new plant ID tool available

The upgrades to the website continue with a new feature added that allows you to use the website to ask others to help identify your plant. Members can now go to the Forum and a new image upload facility allows you to upload an image to the forum and ask others for help.

New species of Fork Fern described

Four named species of *Tmesipteris* fork ferns have been recognised in New Zealand since Bob Chinnock's 1975 revision. Fork ferns are usually epiphytic on tree ferns with *T. tannensis* the only species to take other substrates with any frequency. A fifth undescribed species has been known from Banks Peninsula for the last 20 years, and this has now been formally described as *Tmesipteris horomaka* by Perrie, Brownsey et Lovis (Perrie *et al.* 2010). The epithet *horomaka* is the Maori name for Banks Peninsula where this species was first identified. Check out the website for a fact sheet on the fern.

World's rarest tree gets some help

The tree species known only as *Pennantia baylisiana* could be the rarest plant on earth, with a single tree known to exist on the Three Kings Islands off the coast of New Zealand. Many attempts have been made to propagate the tree, however it appeared that it is a female and needs a male to pollinate and set seed. A rare discovery showed that some propagated trees showed signs of seed setting after manual pollination, leading Peter de Lange to believe that the original tree had some male properties. The aim is now to take 1600 quarantined seeds back to the Islands. The seeds are expected to take 6-10 years to grow large enough to start flowering and the project will continue until there are 500 viable adults.

For more information on any of these items please check out the NZPCN website at <www.nzpcn.org.nz>.

Reference

Perrie, L.R., Brownsey, P.J. and Lovis, J.D. (2010). *Tmesipteris horomaka*, a new octoploid species from Banks Peninsula. *New Zealand Journal of Botany* 48: 15-29.

Book Reviews

A Handbook of the World's Conifers

by Aljos Farjon
Publisher: Brill, Leiden, The Netherlands, 2010
Two Volumes, 1112 pages with botanical drawings, colour plates. Hardback, ISBN: 9789004177185.
Price: € 196.00
Available from: www.brill.nl

A HANDBOOK OF THE WORLD'S CONIFERS
ALJOS FARJON
A HANDBOOK OF THE WORLD'S CONIFERS
ALJOS FARJON

As noted on the Brill website, this newly published book *A Handbook of the World's Conifers* departs from the traditional approach which all too frequently involves a focus on the conifers of temperate Europe and North America. Farjon's Handbook includes all of the world's 615 species of conifers, of which some 200 occur in the tropics, and as such should manage to satisfy readers throughout the world.

The author, Aljos Farjon FLS, is a botanist who studied the taxonomy and ecology of conifers at the University of Utrecht, Oxford University and the Royal Botanic Gardens, Kew. Having retired, he is currently an Honorary Research Associate at Kew. Since 1984 he has published 10 books and 55 scientific papers on conifers.

The Handbook is a sizeable publication that is presented in two volumes—and weighing in at over 4 kg it is definitely not a field guide!

The beginning of Volume 1 provides background on the distribution and ecology, economic importance and conservation of the world's conifers. It then gives a synopsis of families and genera, and a description of the taxonomic treatment of the eight families recognised by Farjon in the Handbook. Farjon notes in the Preface that he has deliberately kept these sections brief as he had already provided a fuller introduction to the world's conifers in his book *A Natural History of Conifers* published in 2008. He also notes that the Handbook does not attempt to describe or illustrate the approximately 15,000 conifer cultivars that are only known in cultivation.

The next section of the Handbook addresses the taxonomic treatment of genera and species, is given in a very easy to use alphabetical order and continues for the next 977 pages! Given the breadth of the plant group and the number of opinions that appear to exist about its taxonomy, it is certainly a pleasure to have a reference book that gives you some confidence in terms of the names you are using (well, for now at least). Not only does this principle section provide valuable information in terms of taxonomy but it is also an immediate and valuable source of information with regards to distribution, ecology, conservation and uses.

The ecology data for each species provide a good feel for the conditions in which it naturally occurs and lists the trees growing with it. The information given on both conservation and uses is extremely valuable in terms of bringing together the sort of detail that is immediately useable in the interpretation of these trees. It is this information that is always most valued by the vast majority of visitors to any living museum and will be of great worth to anyone responsible for education or interpretation in such institutions. It effectively pulls together the type of information that educationists are so frequently trying to source. In addition, the Handbook's extensive glossary is not only of considerable value to non-botanical users but also ventures into a broader range of terminology used in conservation and plant usage.

As well as providing interpretative information, the conservation sections provide details on the conservation status of the conifers, the threats they are facing and some of the actions that are being taken. While the Handbook cannot be expected to give recovery plan detail for the world's conifers, it does appear to provide a good summary of the current situation.

One important issue that does not seem to be addressed in descriptions is weediness. While this could be considered an issue that is not important to an individual conifer species' conservation, conifers are proving to be of considerable concern in relation to the conservation of other species. *Pinus radiata* is a good example. Farjon notes that it is now the "most widely planted tree species in the world" but fails to note that in numerous places it has also been declared a noxious weed. Even just having a list of all the taxa that have a recognised weediness would be valuable. A weediness scoring similar to that used in *The introduced flora of Australia and its weed status* (Randall, 2007, www.iffa.org.au/IFFA-files/intro_flora_australia.pdf) could also be considered. Such information needs to be viewed as of considerable importance to people interested in introducing new species to an area.

As would be expected, the Handbook does not attempt to give illustrations of all the taxa described, but a large number are illustrated. The colour photographs provide close-up images of the foliage and fruit of some taxa and images of habitat for others. The detailed line drawings done by Farjon again demonstrate the depth of feeling that he has for this group of plants.

The Handbook is nothing short of a very impressive botanical publication. It is not just of immediate value to botanists, but also to anyone with an interest in conifers and who is keen to have a way of rapidly gaining information about them. Any institution, group or individual growing conifers as a collection for display or conservation should have a copy of Farjon's *A Handbook of the World's Conifers*.

Mark Richardson, Botanical Consultant, Greenacres, SA.

Book Reviews (cont.)

Temperate Woodland Conservation and Management

Edited by David Lindenmayer, Andrew Bennett
& Richard Hobbs
Publisher: CSIRO Publishing. Collingwood
Victoria, 2010
374 pages. Paperback, ISBN: 9780643100374
Price: AU $89.95
Available from: www.publish.csiro.au

Temperate woodlands once occupied a large geographical area of southern Australia. Since European settlement these lands have been used extensively for various forms of agriculture to the great detriment of many native plant and animal species. The editors of this very worthy book point out that over the past 20 years the plight of temperate woodlands has received growing attention, and an increased focus on the ecology, conservation and importantly management of these systems.

Temperate Woodland Conservation and Management is an excellent book, primarily because it offers the unique insights of a large number of patently committed and passionate ecologists, restorationists, conservationists, natural resource managers and policy makers. Each is invited to give an overview of their particular area of expertise (be it vegetation, bird, reptile, invertebrate or other). In most cases the time each contributor has spent studying and understanding temperate woodlands spans decades. This, together with the attention shown to the many and varied aspects of woodland systems, leaves the reader in no doubt that there is valuable information on offer.

The standard of each chapter is remarkably consistent. Beyond the obvious passion of the contributors, this is aided by a very sensible general format. The decision to keep each chapter relatively short (around 3500 words), and to further break them into a standard structure—beginning with key lessons, an introduction, a discussion of the key lessons and a concluding paragraph—ensures the contents of this book are always easily digestible. Further, each author supports their argument with relevant references. These will be in and of themselves of great use to the reader seeking more detail or explanation. The chapters are then arranged in five parts, attempting to focus topics at national and state levels (both for research, management and policy). Broadly speaking this works and helps to direct a somewhat complex and certainly diverse range of discussions.

What becomes very clear through this book is that the issues involved in the protection, conservation, management and restoration of temperate woodlands are many and varied. In some ways the actions/goals of halting (and even reversing) the decline of these complex ecosystems might seem like something of a mixed-up jigsaw puzzle. Happily, each of the chapters (together with the detailed reference materials) might be akin to many of the pieces of that jigsaw arranged to form a coherent picture. This is not to say there are not some tensions contained within. For example, several authors argue the cause of large-scale action, while others caution that 'big' is not necessarily 'best'. However, broadly speaking most contributors sing from a common hymn book (e.g. the need to conserve what is left, the need to support farmers financially, and the need for increased collaboration between researchers, farmers and enthusiasts). And in the end it is left for the reader to make up their own mind.

I will refrain from identifying any particular chapter or topic, although it is fair to say that I responded to some more than others. I would expect that most readers will like-wise, depending on their particular area of interest. Beyond immediate areas of interest, in total this book offers the reader an opportunity to view temperate woodlands across a number of contexts, many of which may not have been previously understood or recognised. This in itself is a worthy achievement. The concluding chapter is useful, if somewhat dry. I suspect that by this time the reader has formed their own opinions (which is not to say the conclusions of such an esteemed editorial team should be ignored!).

In summary, I would recommend this book highly. It is bound to be of great value to a large and diverse group of people interested in the plight of this landscape. It offers both theoretical and practical insights, but perhaps most admirably, draws a metaphorical 'line in the sand' and points the way to a much brighter future.

Paul Gibson-Roy, Ecologist & Restorationist, Melbourne, Vic.

Book Reviews (cont.)

Forest Phoenix: How a great forest recovers after wildfire

by David Lindenmayer, David Blair, Lachlan McBurney and Sam Banks
Publisher: CSIRO Publishing, Collingwood, Victoria, 2010
128 pages with colour illustrations and line art
Paperback, ISBN: 9780643100343. Price: AU $39.95
Available from: www.publish.csiro.au

This book is the legacy of decades of ecological research in the wet montane ash forests of central Victoria north-east of Melbourne where the authors have been working since 1983. After many years of data collection in long-term ecological research projects, many of their study sites were burnt in the Black Saturday bushfires on 7 February 2009. The fires provided an opportunity to study the effects of the fire and the recovery of the vegetation and wildlife, and the book was produced to tell the wider community about this.

The book directly addresses the issue that particularly concerns and irritates me, i.e. that bushfire 'destroys' the forest. This is certainly not so, and the authors make a very clear case that the vegetation and habitat "does not (and cannot) recover from a 'clean slate'". Native vegetation and forest always "recover" after a fire in different ways depending on the "biological legacy" in any one site or landscape.

The biological legacy of a site is the basis of vegetation and habitat recovery and includes "living and dead standing trees, logs, plants, seeds, rhizomes or rootstocks, fungi, bacteria, and animals which often survive ...". This concept of biological legacy is very important in the context of these forests and to some degree in any site where restoration of native vegetation is being considered. This book highlights the importance of biological legacies in vegetation recovery through strategic text and extensive and well-selected pictures.

The book is divided into four sections. Each chapter has an engaging theme supported by minimal but eloquent and informative text.

Chapter 1 describes the vegetation that is present and the fires that affected the Central Highlands of Victoria on Black Saturday in February 2009. It also describes the severity and sometimes selective impacts of the fire. The pictures provided are quite striking and the chapter is a fantastic introduction to a large scale bushfire and its impacts.

Chapter 2 is called "after the fire – a forest recovers". This chapter is a wonderful and clear overview of fire ecology in montane ash forests in particular and Australian vegetation in general. It summarises how plants respond after fires—some survive and resprout, i.e. "survivors", and others come back from seeds, i.e. the "germinators". Again the selected pictures tell an amazing story, including epicormic growth and the potential of the often unseen seed resource in the soil and canopy.

Chapter 3 provides an overview about how the wildlife recovers. This chapter quite specifically addresses another myth about bushfire, i.e. the assumption that all animals are killed and that habitat is substantially lost indefinitely. The authors' research busts this myth very effectively, because the reality is that the response of fauna varies a great deal. The authors start by highlighting the perhaps surprising story that they fitted radio collars to 19 Mountain Brushtail Possums near Cambarville the week before the fires and subsequently found that all 19 survived the wildfire. They also found that one bird species, i.e. the Flame Robin, moved into "almost every stand of burnt forest". Their work showed that several factors, including logs, hollows and unburnt patches, are critical to the recovery of fauna in the burnt landscapes, with hollows being particularly important for many species. The authors highlight the findings that trees can take up to 80 years to decay after death, providing habitat for much of that time, and that fire can accelerate the loss of logs and stags providing important habitat.

Chapter 4 talks about the future of the montane ash forests. The authors make the important point that the long-term fire regime shapes the vegetation rather than any individual fire event. The values of the montane ash forests of Central Victoria are reviewed, including biodiversity, recreation, water production, carbon storage and wood and paper production, and the conflicts between them. The point is made that most of these values easily coexist but "management of these forests for timber and pulpwood production involves major human disturbances that can have significant tradeoffs for other values." "Research in rainforest and other kinds of very wet forest around the world suggests that logging makes them more fire-prone" and the reasons are detailed.

The context for the authors' research and the fires are the forests where intensive debate over logging is ongoing. This is of course because these forests are among the most productive in Victoria resulting in a great deal of economic activity through timber harvesting. They are also the most evocative for the general public because of their scale and presence and the other important values they provide (despite many other vegetation types being much rarer and more at risk). The research behind this book informs the debate with credible interpretation of scientific information

Book Reviews (cont.)

but is designed to be read and understood by an audience well beyond scientists.

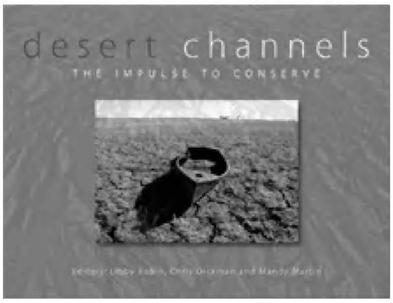
The many beautiful and stunning pictures dominate the book and eloquently tell the stories of the fire and forest ecology. The authors use sequential photographs very effectively in many cases to indicate dramatic contrasts in time and conditions. A good picture can be worth many words, and the authors have selected many excellent pictures to tell the important facts and stories so that they can leave the text short and to the point.

This is an excellent book that I believe provides several elements that would satisfy different readers as well as different perspectives in the one reader. As a professional ecologist I was able to appreciate the scientific information and add to my existing knowledge of fire ecology. As a resident of Victoria who has experienced the forest and the fires I gained a deeper appreciation of the drama of the fire itself and the recovery of the vegetation and wildlife. The book has many lessons for people concerned about biodiversity around Australia and beyond by describing the complexity of "post-fire ecological recovery" and by "also trying to simplify the science in a way that makes the complexity understandable".

Lincoln Kern, Practical Ecology Pty Ltd, Preston, Vic.

Desert Channels: The Impulse to Conserve

Edited by Libby Robin, Chris Dickman and Mandy Martin
Publisher: CSIRO Publishing, Collingwood, Victoria, September 2010
352 pages with colour illustrations and line art
Hardback, ISBN: 9780643097490. Price: AU$59.95
Available from: www.publish.csiro.au



Desert Channels is presented in landscape format, which could give the impression that it is a 'coffee table' book. It has great images, mostly landscape photos, and some other artwork, though these are mainly presented as sets of four small images called 4x4s (an apparent reference to the role that four-wheel-drive vehicles play in travelling through and within the Desert Channels region). Disappointingly, full-page images are relatively rare, and the much smaller images do not necessarily do their subject justice. The subject area of the book is the 'channel country' of south-western Queensland drained by the Diamantina and Georgina Rivers, and by Cooper Creek and its tributaries, the Barcoo and Thomson rivers.

The book is written by a large number of authors, some of whom make very small contributions, whilst others have written a chapter or several sections. The editors are also authors and/or co-authors of at least one chapter each, with ecologist, Chris Dickman being the most prolific contributor. The standard of writing is generally high, though the work of some authors is far easier to read than that of others.

The quality of information provided is high, though there are some deficiencies in a minority of arguments that are put by some authors, and there is a bit of platitudinous waffle in the Prologue. For example, "Conserving a (human) community is good for biodiversity, and respecting cultural heritage does not mean losing natural diversity" (p. xvi), reads like an attempt to please everyone whilst not dealing with the fact that there can be situations where human communities are not good for indigenous biodiversity, and where particular forms or interpretations of cultural heritage (e.g. cattle grazing in the Australian Alps) can cause biodiversity loss.

There is a lack of sufficiently comprehensive critical rigour in some sections, which has meant that a small number of unsound or at least highly contentious claims are made in what is otherwise a well-referenced and scholarly book.

An example of an unsubstantiated and self-interested claim made by one minor author is that cattle and sheep grazing in the region is sustainable (p. 261). This claim clashes with more learned views provided elsewhere in the book, but it is left unchallenged. Similarly, on page 287, the author claims "… nature (sic) looks increasingly cultural" and that "There is no such thing as a landscape untouched by humans". The first claim more than hints at the problematic division between 'natural' and 'cultural' that is not adequately explored in this book. The second claim is made in the context of highlighting the extent and duration of Aboriginal occupation of Australia, but it fails to deal with evidence that some parts of the country had no Aboriginal visitation or management. On page 289, the author writes, "All states appear to struggle in financing the ongoing operational cost of (conservation) reserves". His point is important, but he fails to recognise that the states *consciously choose* not to devote adequate funds to this end, presumably because governments' perceptions of politics dictates that doing so is not expedient.

Book Reviews (cont.)

Some of the deficiencies of argument are philosophically problematic, and point to the deep-seated anthropocentrism of Western culture, even in the midst of a book that seemingly purports to be about well-founded and inclusive environmentalism. I am not sure though that all of the authors would be comfortable with describing themselves or the central argument of the book as environmentalist.

A significant weakness in most of the material that deals with the motivations to conserve aspects of the Desert Channels region is the failure to recognise, at least overtly, the intrinsic worth of indigenous species and landscapes. The exception is Libby Robin's comment on page 314 of the final chapter. Elsewhere, justifications for the conservationism include 'environmental services', i.e. how parts of Nature or natural systems benefit humans; and the aesthetic merit of Nature and its components (again, an anthropocentric view).

The editors could have done more to ensure that philosophically weak, underdeveloped, and prejudiced comments were challenged or at least contrasted in follow-up chapters or in one of the many short pieces of text that are interspersed within the chapters. The editorial team would have benefited from the insights of an environmental philosopher or at least someone familiar with the core of that literature.

Most of the book's content is of a scientific nature, for example, ecological, geological, hydrological, palaeontological, and climatic information. A smaller portion deals with cultural heritage, Aboriginal and otherwise, and some deep and fascinating insights are provided by that material. Mandy Martin's insights as a visual artist are presented as four 'Interludes' between the chapters, and in part serve to highlight the aesthetic values of the region, and how art can be a powerful communication tool in promoting a conservation ethic.

Disappointingly, relatively little is written on the theme of the book's subtitle, 'the impulse to conserve'. Despite its subtitle and some of the earlier text, *Desert Channels* is not dominated by a discussion of what motivates people to protect the human and non-human values of this highly variable but primarily arid landscape. Perhaps the editors and authors would argue that the ecological and cultural heritage sections serve as background information that explains why and how people have sought to conserve various aspects of the region. Unfortunately, such material is not adequately woven together into an explanation of the impulse to conserve.

I found the layout of the book problematic. Chapters are often interrupted by shorter sections of text that sometimes provide information by another author or authors about a particular item or issue of interest. The interruption is annoying because it breaks the flow of the chapter. A reader can turn a page within a chapter and find that the text they intend to continue reading has been interrupted, by other text.

The book's format means that a reader does not have to progress from cover to cover. Most of the chapters and perhaps all of the short insert sections can be read opportunistically. This feature makes it a bit more like a good 'coffee table' book, but some of the chapters may be too long and/or technical for this purpose.

Desert Channels contains diverse, relatively accessible, and frequently interesting content. Its format and layout is perhaps original, but ultimately, it is not a particularly good 'coffee table' book because it lacks sufficient full-page images, and much of the text is too lengthy or technical for that purpose. It is useful for the technical information that it provides, though it is not a technical manual or 'text book'.

It raises some very worthy themes such as the role of art in promoting and sustaining relatively grounded environmentalism, and as a driver for conservationism. It also gives weight to Aboriginal views and values, and it rightly promotes the cause of 'off reserve conservation' and of meaningful partnerships between a diversity of individuals and groups interested in conserving at least some attributes of the Channel Country.

However, the book could have achieved much more in terms of weaving together the various motivations for conservation, and it could have dealt with some underlying and unchallenged philosophical problems associated with some of those motivations.

Steve Douglas, Ecological Surveys & Planning, Exeter, NSW.

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A workshop on the translocation of threatened plant species will be held in Melbourne in May. Register your interest in attending the course by contacting ANPC at anpc@anpc.asn.au or phoning 02 6250 9509.

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This project will involve conducting six, two-day workshops over three years to engage on-ground managers of travelling stock reserves to increase their ecological knowledge and plant conservation skills. The first workshop will be held in the Wagga region, NSW in March/April this year. Course materials will also be developed as a resource for further workshops and other training opportunities outside the project funding and which could also be applied to other linear reserve management. For further information, contact Sue Mathams on phone 02 6250 9523 or email sue.mathams@environment.gov.au.

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Australasian Plant Conservation

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